MAR 15 1983

A

EPA

POTENTIAL HAZARDOUS WASTE SITE IDENTIFICATION AND PRELIMINARY ASSESSMENT

REGION | SITE NUMBER (to be assigned by Hq)

NOTE: This form is completed for each potential hazardous waste site to help set priorities for site inspection. The information submitted on this form is based on available records and may be updated on subsequent forms as a result of additional inquiries and on-site inspections.

GENERAL INSTRUCTIONS: Complete Sections I and III through X as completely as possible before Section II (*Preliminary Assessment*). File this form in the Regional Hazardous Waste Log File and submit a copy to: U.S. Environmental Protection Agency; Site Tracking System; Hazardous Waste Enforcement Task Force (*EN-335*); 401 M St., SW; Washington, DC 20460.

I. SITE IDENTIFICATION

SC957002432 BERKELEY
DEFENSE ~~FUEL SUPPORT POINT~~ CHARLES
NORTH RHETT AVE
HANAHAN SC 29406

B. STREET (or other identifier)

D. STATE | E. ZIP CODE | F. COUNTY NAME

2. TELEPHONE NUMBER

H. TYPE OF OWNERSHIP

[X] 1. FEDERAL [ ] 2. STATE [ ] 3. COUNTY [ ] 4. MUNICIPAL [ ] 5. PRIVATE [ ] 6. UNKNOWN

I. SITE DESCRIPTION

J. HOW IDENTIFIED (*i.e., citizen's complaints, OSHA citations, etc.*)

K. DATE IDENTIFIED (*mo., day, & yr.*)

L. PRINCIPAL STATE CONTACT

1. NAME

2. TELEPHONE NUMBER

II. PRELIMINARY ASSESSMENT (*complete this section last*)

A. APPARENT SERIOUSNESS OF PROBLEM

[ ] 1. HIGH [ ] 2. MEDIUM [ ] 3. LOW [ ] 4. NONE [X] 5. UNKNOWN

B. RECOMMENDATION

[ ] 1. NO ACTION NEEDED (*no hazard*)

[ ] 2. IMMEDIATE SITE INSPECTION NEEDED
a. TENTATIVELY SCHEDULED FOR:
b. WILL BE PERFORMED BY:

[X] 3. SITE INSPECTION NEEDED
a. TENTATIVELY SCHEDULED FOR:
b. WILL BE PERFORMED BY:

[ ] 4. SITE INSPECTION NEEDED (*low priority*)

C. PREPARER INFORMATION

1. NAME WS

2. TELEPHONE NUMBER

3. DATE (*mo., day, & yr.*) 1/28/83

III. SITE INFORMATION

A. SITE STATUS

[ ] 1. ACTIVE (*Those industrial or municipal sites which are being used for waste treatment, storage, or disposal on a continuing basis, even if infrequently.*)

[ ] 2. INACTIVE (*Those sites which no longer receive wastes.*)

[ ] 3. OTHER (*specify*): (*Those sites that include such incidents like "midnight dumping" where no regular or continuing use of the site for waste disposal has occurred.*)

B. IS GENERATOR ON SITE?

[ ] 1. NO [ ] 2. YES (*specify generator's four-digit SIC Code*):

C. AREA OF SITE (*in acres*)

D. IF APPARENT SERIOUSNESS OF SITE IS HIGH, SPECIFY COORDINATES

1. LATITUDE (*deg.-min.-sec.*)

2. LONGITUDE (*deg.-min.-sec.*)

E. ARE THERE BUILDINGS ON THE SITE?

[ ] 1. NO [ ] 2. YES (*specify*):

T2070-2 (10-79)

Continue On Reverse

Continued From Front

IV. CHARACTERIZATION OF SITE ACTIVITY

Indicate the major site activity(*ies*) and details relating to each activity by marking 'X' in the appropriate boxes.

'X'	A. TRANSPORTER	'X'	B. STORER	'X'	C. TREATER	'X'	D. DISPOSER
	1. RAIL		1. PILE		1. FILTRATION		1. LANDFILL
	2. SHIP		2. SURFACE IMPOUNDMENT		2. INCINERATION		2. LANDFARM
	3. BARGE		3. DRUMS		3. VOLUME REDUCTION		3. OPEN DUMP
	4. TRUCK		4. TANK, ABOVE GROUND		4. RECYCLING/RECOVERY		4. SURFACE IMPOUNDMENT
	5. PIPELINE		5. TANK, BELOW GROUND		5. CHEM./PHYS. TREATMENT		5. MIDNIGHT DUMPING
	6. OTHER (*specify*):		6. OTHER (*specify*):		6. BIOLOGICAL TREATMENT		6. INCINERATION
					7. WASTE OIL REPROCESSING		7. UNDERGROUND INJECTION
					8. SOLVENT RECOVERY		8. OTHER (*specify*):
					9. OTHER (*specify*):		

E. SPECIFY DETAILS OF SITE ACTIVITIES AS NEEDED

V. WASTE RELATED INFORMATION

A. WASTE TYPE

☐ 1. UNKNOWN ☐ 2. LIQUID ☐ 3. SOLID ☐ 4. SLUDGE ☐ 5. GAS

B. WASTE CHARACTERISTICS

☐ 1. UNKNOWN ☐ 2. CORROSIVE ☐ 3. IGNITABLE ☐ 4. RADIOACTIVE ☐ 5. HIGHLY VOLATILE
☐ 6. TOXIC ☐ 7. REACTIVE ☐ 8. INERT ☐ 9. FLAMMABLE

☐ 10. OTHER (*specify*):

C. WASTE CATEGORIES

1. Are records of wastes available? Specify items such as manifests, inventories, etc. below.

2. Estimate the amount(*specify unit of measure*) of waste by category; mark 'X' to indicate which wastes are present.

a. SLUDGE	b. OIL	c. SOLVENTS	d. CHEMICALS	e. SOLIDS	f. OTHER
AMOUNT	AMOUNT	AMOUNT	AMOUNT	AMOUNT	AMOUNT
UNIT OF MEASURE	UNIT OF MEASURE	UNIT OF MEASURE	UNIT OF MEASURE	UNIT OF MEASURE	UNIT OF MEASURE
'X' (1) PAINT, PIGMENTS	'X' (1) OILY WASTES	'X' (1) HALOGENATED SOLVENTS	'X' (1) ACIDS	'X' (1) FLYASH	'X' (1) LABORATORY PHARMACEUT.
(2) METALS SLUDGES	(2) OTHER(*specify*):	(2) NON-HALOGNTD. SOLVENTS	(2) PICKLING LIQUORS	(2) ASBESTOS	(2) HOSPITAL
(3) POTW		(3) OTHER(*specify*):	(3) CAUSTICS	(3) MILLING/ MINE TAILINGS	(3) RADIOACTIVE
(4) ALUMINUM SLUDGE			(4) PESTICIDES	(4) FERROUS SMLTG. WASTES	(4) MUNICIPAL
(5) OTHER(*specify*):			(5) DYES/INKS	(5) NON-FERROUS SMLTG. WASTES	(5) OTHER(*specify*):
			(6) CYANIDE	(6) OTHER(*specify*):	
			(7) PHENOLS		
			(8) HALOGENS		
			(9) PCB		
			(10) METALS		
			(11) OTHER(*specify*)		

 Continue On Page 3

Continued From Page 2

V. WASTE RELATED INFORMATION *(continued)*

3. LIST SUBSTANCES OF GREATEST CONCERN WHICH MAY BE ON THE SITE *(place in descending order of hazard).*

4. ADDITIONAL COMMENTS OR NARRATIVE DESCRIPTION OF SITUATION KNOWN OR REPORTED TO EXIST AT THE SITE.

VI. HAZARD DESCRIPTION

A. TYPE OF HAZARD	B. POTENTIAL HAZARD *(mark 'X')*	C. ALLEGED INCIDENT *(mark 'X')*	D. DATE OF INCIDENT *(mo., day, yr.)*	E. REMARKS
1. NO HAZARD				
2. HUMAN HEALTH				
3. NON-WORKER INJURY/EXPOSURE				
4. WORKER INJURY				
5. CONTAMINATION OF WATER SUPPLY				
6. CONTAMINATION OF FOOD CHAIN				
7. CONTAMINATION OF GROUND WATER				
8. CONTAMINATION OF SURFACE WATER				
9. DAMAGE TO FLORA/FAUNA				
10. FISH KILL				
11. CONTAMINATION OF AIR				
12. NOTICEABLE ODORS				
13. CONTAMINATION OF SOIL				
14. PROPERTY DAMAGE				
15. FIRE OR EXPLOSION				
16. SPILLS/LEAKING CONTAINERS/ RUNOFF/STANDING LIQUIDS				
17. SEWER, STORM DRAIN PROBLEMS				
18. EROSION PROBLEMS				
19. INADEQUATE SECURITY				
20. INCOMPATIBLE WASTES				
21. MIDNIGHT DUMPING				
22. OTHER *(specify):*				

Continued From Front

VII. PERMIT INFORMATION

A. INDICATE ALL APPLICABLE PERMITS HELD BY THE SITE.

☐ 1. NPDES PERMIT ☐ 2. SPCC PLAN ☐ 3. STATE PERMIT *(specify)*: ____
☐ 4. AIR PERMITS ☐ 5. LOCAL PERMIT ☐ 6. RCRA TRANSPORTER
☐ 7. RCRA STORER ☐ 8. RCRA TREATER ☐ 9. RCRA DISPOSER
☐ 10. OTHER *(specify)*: ____

B. IN COMPLIANCE?

☐ 1. YES ☐ 2. NO ☐ 3. UNKNOWN

4. WITH RESPECT TO *(list regulation name & number)*: ____

VIII. PAST REGULATORY ACTIONS

☐ A. NONE ☐ B. YES *(summarize below)*

IX. INSPECTION ACTIVITY *(past or on-going)*

☐ A. NONE ☐ B. YES *(complete items 1,2,3, & 4 below)*

1. TYPE OF ACTIVITY	2. DATE OF PAST ACTION *(mo., day, & yr.)*	3. PERFORMED BY: *(EPA/State)*	4. DESCRIPTION

X. REMEDIAL ACTIVITY *(past or on-going)*

☐ A. NONE ☐ B. YES *(complete items 1, 2, 3, & 4 below)*

1. TYPE OF ACTIVITY	2. DATE OF PAST ACTION *(mo., day, & yr.)*	3. PERFORMED BY: *(EPA/State)*	4. DESCRIPTION

NOTE: Based on the information in Sections III through X, fill out the Preliminary Assessment *(Section II)* information on the first page of this form.

DEFENSE LOGISTICS AGENCY
DEFENSE FUEL SUPPLY CENTER
CAMERON STATION
ALEXANDRIA, VIRGINIA 22304-6160

14 NOV 1991

IN REPLY REFER TO DFSC-FQ

U. S. Environmental Protection Agency
Region IV
RCRA & Federal Facilities Branch
Waste Management Division
Attn: Mr. J. C. Meredith
345 Courtland Street, N. E.
Atlanta, GA 30365

Dear Mr. Meredith:

In response to your letter dated September 13, 1991, we have completed the Preliminary Assessment Update for our Defense Fuel Support Point (DFSP) Charleston, 5862 N. Rhett Avenue, Hanahan, SC. The following information was derived from reports of various environmental site assessments conducted at the fuel terminal as the result of a leak of 83,000 gallons of jet fuel into the soil and groundwater in September 1975.

After the 1975 release, approximately 20,000 gallons were immediately recovered from the groundwater. Subsequent efforts did not yield any further recovery of fuel product and in February 1976 the incident was considered closed. The first post fuel leak study conducted in 1977 indicated only residual contamination of the soil and that fuel-eating microbes were active in all samples tested. No further cleanup action was required. After a 200 year rainfall event in 1979, residents to the north of the fuel terminal detected fuel odors. Consequently, the U. S. Air force and later, the Defense Fuel Supply Center (DFSC) contracted for various studies to define the extent of the contamination, analyze the risks to human health and the environment, evaluate the hydrogeology of the site, and to evaluate and select the best remedial alternatives to clean up the contamination. Reports on these studies are enclosed.

The South Carolina Department of Health and Environmental Control (SCDHEC) has been actively involved in the evaluation of the data generated from the studies and has recommended that the combination of a pump and treat and an enhanced bioremediation system would work best to clean up the remaining contamination. Construction of the system is complete and pending final approval by the SCDHEC, the system should be operational early in 1992. This system will serve both to prevent further migration of the plume of contamination and to clean up the site. As a condition of the construction permit issued by the SCDHEC, the U.S. Geological Survey (USGS) has developed an extensive and continuous monitoring program designed to assess the effectiveness of the remediation system and determine the length of time required to accomplish remediation. In addition, the USGS will conduct a complete well survey to obtain an accurate groundwater flow map.

Although petroleum contamination is exempt from CERCLA requirements, the environmental assessment process employed at DFSP Charleston followed the same EPA guidance as that of a PA/SI. The enclosed reports and checklist describe the extent of the petroleum hydrocarbon contamination; address the groundwater, surface water, and air pathways for the contamination; and identify the targets. In 1987, IFC-Clement Associates, Fairfax, Virginia, prepared a risk assessment of exposure to the contamination.

To summarize the data from the reports in the PA/SI format we have included the SSI Phase I Reconnaissance Documentation Checklist as the first enclosure to this letter. Briefly, we would like to offer the following comments in regard to some of the checklist items pertinent to this site.

DFSC maintains that state and federal environmental compliance issues always be a top priority and has completed many rehabilitation projects at DFSP Charleston to ensure future compliance of the terminal. The cleaning, repair, and renovation of tank bottoms, roofs, and drainage systems underlines our interest in running a clean, efficient, and odor free terminal. These measures serve to prevent leaks from occurring and that the soil, ground water and surface water be protected from contamination.

Based upon the hydrogeologic study of the site and the surrounding area, the groundwater pathway has been determined to be confined to the shallow aquifer, which ranges from 20 to 35 feet thick, and moves north-northeasterly at a rate of 0.24 ft/day. At this rate, groundwater at the tank farm fence would take 13 years to travel to Gold Cup Lake. There are no drinking water wells in the vicinity but there are six wells used for lawn irrigation and to fill swimming pools. The reservoir which supplies drinking water to the Hanahan community is to the northwest but is several miles upgradient of the fuel terminal.

In regard to surface water pathways, there is one intermittent drainage ditch on the east side of the terminal which flows north toward Gold Cup Lake. Any runoff first passes through an oil/water separator before leaving the fuel terminal.

As cited previously, ICF-Clement Associates completed a Health Risk Assessment in 1987 and advised that the short-term risk to health, under average conditions of exposure, is insignificant. The consultants analyzed the potential longterm health risks in Gold Cup Springs subdivision using the following assumptions:

1. Each resident drank approximately two quarts of well water each day for 70 years.

2. Each resident swam for 30 minutes a day, 4 days a week, 6 months a year for 70 years in swimming pools filled with well water.

3. Each resident spent 16 hours a day for 70 years breathing neighborhood air.

4. That the amount of benzene in the groundwater remained constant and that the groundwater was not treated.

ICF-Clement Associates concluded that a resident who did these things for 70 years might be exposed to a potential lifetime health risk.

As long as residents use municipal water for drinking, bathing, and swimming, the only actual exposure to the benzene comes from breathing the neighborhood air. ICF-Clement associates concluded that the noncancer risk from breathing this air is insignificant. With respect to the cancer risk, they noted that the normal background lifetime risk of cancer is 25%, meaning that approximately 25% of all people in the United States develop cancer in their lifetimes. They concluded that the lifetime risk from breathing the benzene in the air would be three additional cases of cancer in 10,000. In comparison, this risk is 33 times lower than the risk of dying from normal air pollution. The consultants also emphasized that this cancer risk is likely to be overstated due to their conservative assumptions. The true risk of cancer could be even lower.

In regard to other areas of petroleum contamination discovered in previous studies, the Naval Facilities Engineering Command has contracted a study of two areas located to the east and west of the tank farm to determine the extent of the contamination both vertically and horizontally. Alternatives will be evaluated to determine the best cleanup system for these areas. This may incorporate the present system or it may be a totally separate operation.

If you have any questions in regard to the letter and the enclosers, please contact Mr. Wayne J. Barnum at telephone number (703) 274-6579.

Sincerely,

W. E. GOODE
Chief, Environmental Quality Division
Directorate of Facilities Management

3 Encls

SSI PHASE I
RECONNAISSANCE DOCUMENTATION CHECKLIST

This information is required for all SSI Phase Is. Much of it will be detailed in your letter report, logbook, or topo map. In such cases, provide only brief descriptions and reference citations on the checklist to avoid duplication. Cite the source for all information obtained for all sections. Lists of HRS-specific definitions and sensitive environment identifications are attached.

Site Name: DEFENSE FUEL SUPPORT POINT CHARLESTON

City, County, State: HANAHAN, BERKELEY COUNTY, SOUTH CAROLINA

EPA ID No.: SC9570024332

Person responsible for form: WAYNE BARNUM

Date: NOVEMBER 1, 1991

DESKTOP DATA COLLECTION
(Can be done before or after recon. Include attachments as necessary).

I. **Groundwater Use** (See project geologist for this information)

- Identify aquifer(s) of concern.

SHALLOW, UNCONFINED AQUIFER OCCURS IN THE UNCONSOLIDATED PLEISTOCENE SEDIMENTS OVERLYING THE COOPER MARL FORMATION.

(REF. FINAL REPORT, AQUIFER EVALUATION, JAN 88, RMT I...

- Identify any areas of karst terrain within the 4-mile site radius, and confining layers and hydraulic interconnections within 2 miles of the site.

NO KARST. CONFINING UNIT COOPER MARL FORMATION

(REF. FINAL REPORT, AQUIFER EVALUATION, JAN 88, RMT INC.)

II. **Surface Water Use**

- Identify uses along the 15-stream-mile surface water pathway (i.e. drinking water, fishing, irrigation, industrial).

FISHING, BOATING, IRRIGATION.

(REF. TOPO & SITE MAPS)

- Identify any designated recreational areas, sensitive environments, and fisheries along the surface water pathway. Specify whether fishing is recreational, subsistence, or commercial. Information for smaller water bodies can be confirmed or obtained from local sources during the recon.

(1) FISHING ALONG GOOSE CREEK - RECREATIONAL. FISHING IN COOPER RIVER IS COMMERCIAL & RECREATIONAL.

(2) (DANIEL ISLAND) WILDLIFE PRESERVE - 6 MI EAST OF TERMINAL - ACROSS COOPER RIVER

(SEE TOPO)

III. **Sensitive Environments**

- Identify any sensitive environments within 4 radial miles of the site (See Table 4-23 of the February 15, 1990 HRS Draft Final Rule, attached). Remember, sensitive environments are not limited to critical habitats.

GOLD CUP SUBDIVISION HAS MAN-MADE LAKE – LOCATED DOWN GRADIENT WITHIN ½ MI TO NORTH OF TERMINAL. COOPER RIVER & GOOSE CREEK ARE BOOTH WITHIN 1½ MI OF TERMINAL. (REF TOPO & RMT AQUIFER EVALUATION -FINAL REPORT-1988)

DRIVE-BY RECONNAISSANCE DATA COLLECTION
(This information should be recorded in logbooks with attachments).

I. **Groundwater Use** (This information can generally be obtained from local water departments, or city hall in rural areas).

- Identify on copies of topos the extent of all municipal systems and areas served by private wells within 4 miles of the site.

3 PRIVATE WELLS IN GOLD CUP SUBDIVISION AND WITHIN 1MI OF TERMINAL. NOT USED FOR DRINKING WATER, BUT TO FILL SWIMMING POOLS & IRRIGATE LAWNS. DRINKING WATER IS FROM PUBLIC SOURCE.

REF. RMT STUDY - AQUIFER FINAL REPORT 1988

- Locate on copies of topos all municipal well locations in the site area, including any wells of a blended system >4 miles from site. Specify if water from these wells is partially or fully blended prior to or during distribution, and if any surface water intakes contribute to a blended system (whether or not they draw from the target sw pathway).

MUNICIPAL WATER SUPPLIED FROM RESERVOIR LOCATED AT SOURCE OF GOOSE CREEK - NORTH OF TERMINAL. NO MUNICIPAL WELLS.

(SEE SITE MAP)

- Note the depth, pumpage, and population served for all municipal wells within the 4-mile site radius. Complete well survey forms.

NOT APPLICABLE

- Document other groundwater uses (e.g. irrigation, industrial).

GROUNDWATER FROM 3 PRIVATE WELLS IS USED FOR SWIMMING POOLS AND LAWN IRRIGATION. NOT FOR DRINKING OR BATHING OR OTHER DOMESTIC USES.

II. **Surface Water Use**

- Identify on topos the 15-mile surface water pathway.

·· COOPER RIVER

·· GOOSE CREEK

·· INTERMITTENT DRAINAGE DITCH

(REF TOPO & WELL LOCATION MAP
RMT AQUIFER EVALUATION
FINAL REPORT 1988)

- Identify and locate on topos any surface water intakes within 15 miles downstream of the site (to be obtained from local water department).

NO SURFACE WATER INTAKES DOWNSTREAM. WATER BRACKISH TIDAL INFLUENCE ON COOPER RIV[illegible] AND GOOSE CREEK

(SEE SITE MAP)

III. **Site and Area Use Data Collection** (May be obtained before or during recon)

- Describe any barriers to travel (e.g. rivers) within 1 mile of the site (consult topo).

COOPER RIVER IS APPROXIMATELY 1.5 - 2.0 MILES FROM SITE.

(SEE TOPO)

- Describe population within the immediate site vicinity and within the 4-mile radius (e.g. sparsely populated rural areas, commercial/industrial areas, densely populated urban areas, etc.).

RESIDENTIAL SUBDIVISION TO IMMEDIATE NORTH, ~~[illegible]~~ U.S MILITARY RESERVATION TO EAST, INDUSTRIAL/COMMERCIAL TO SOUTH & WEST.

- Obtain aerial photos of site and immediate vicinity whenever available (from county offices).

NO AERIAL PHOTOS AVAILABLE.

- Note if the facility is on sewers or septic tanks (consult water or public works department).

CITY SEWER & WATER.

(VERIFIED BY CONTACTING FACILITY OPERATOR.)

- Obtain current property owner information from the county tax assessor's office.

PROPERTY OWNER: CHARLESTON AIR FORCE BASE PH # (803) 566-4976
437 SUPPORT GROUP / DEEV
CHARLESTON AFB, SC 29404-5045

FACILITY ADMINISTRATOR: DEFENSE FUEL SUPPLY CENTER
DFSC-FQ PH # (703) 274-6579
CAMERON STATION,
ALEXANDRIA, VA 22304

FACILITY OPERATOR: CONTINENTAL SERVICE CO. PH # (803) 744-3054
N. RHETT EXT.
HANAHAN, SC 29406

SITE MAP

Environmental Quality Surv and Spill Plans Implementation Rev Study
No. 32-24-7070-88, 1-5 Feb 88

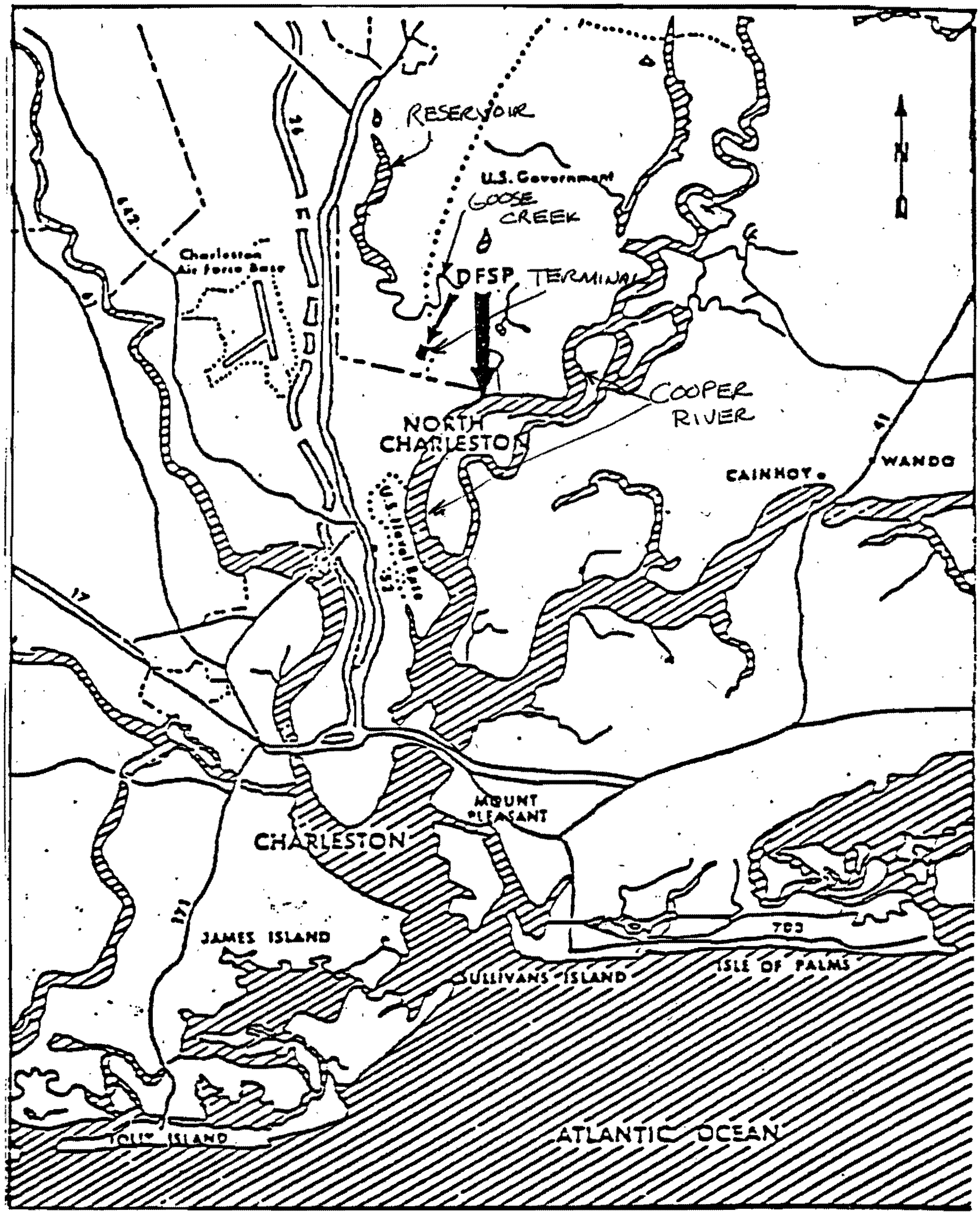
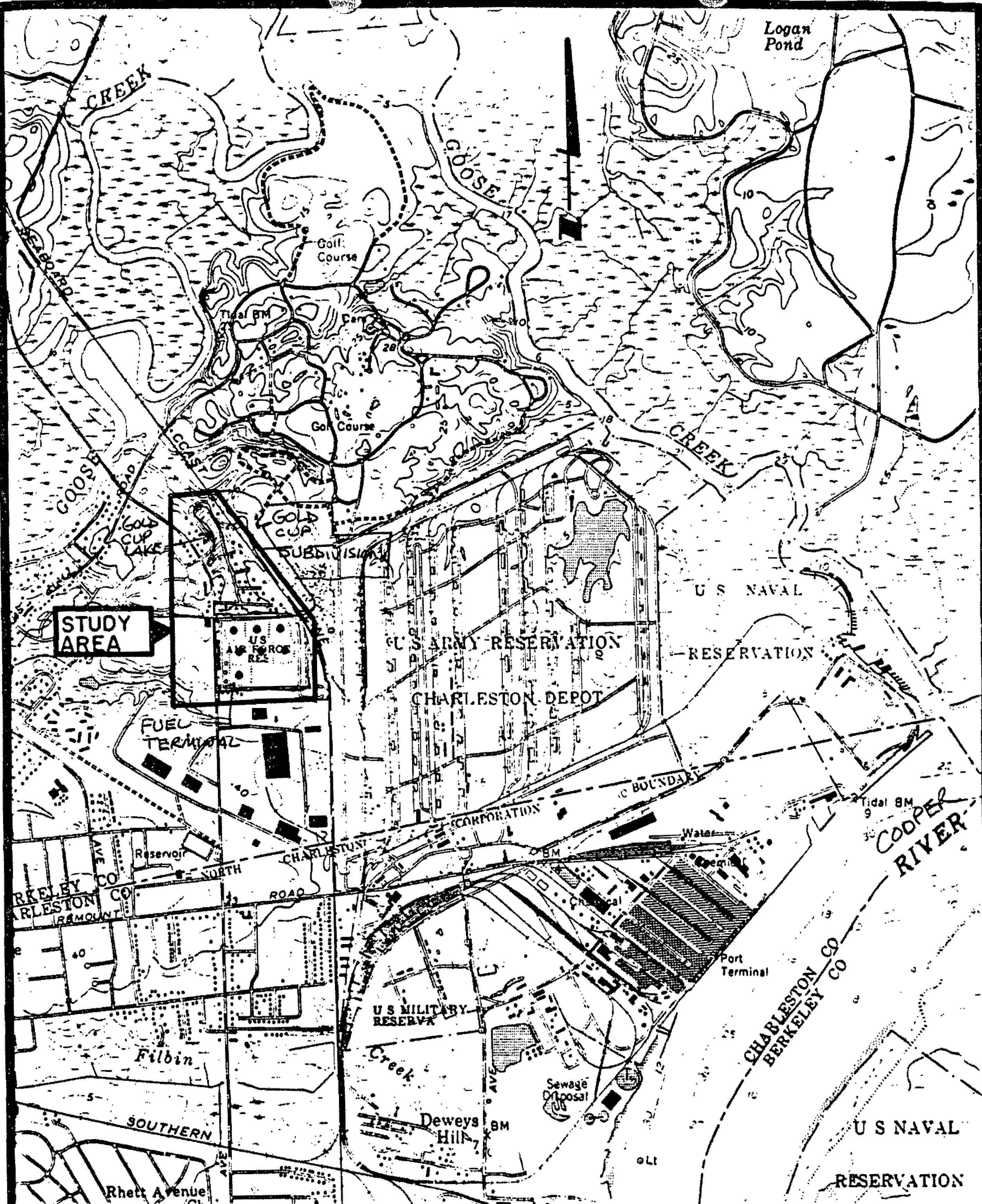
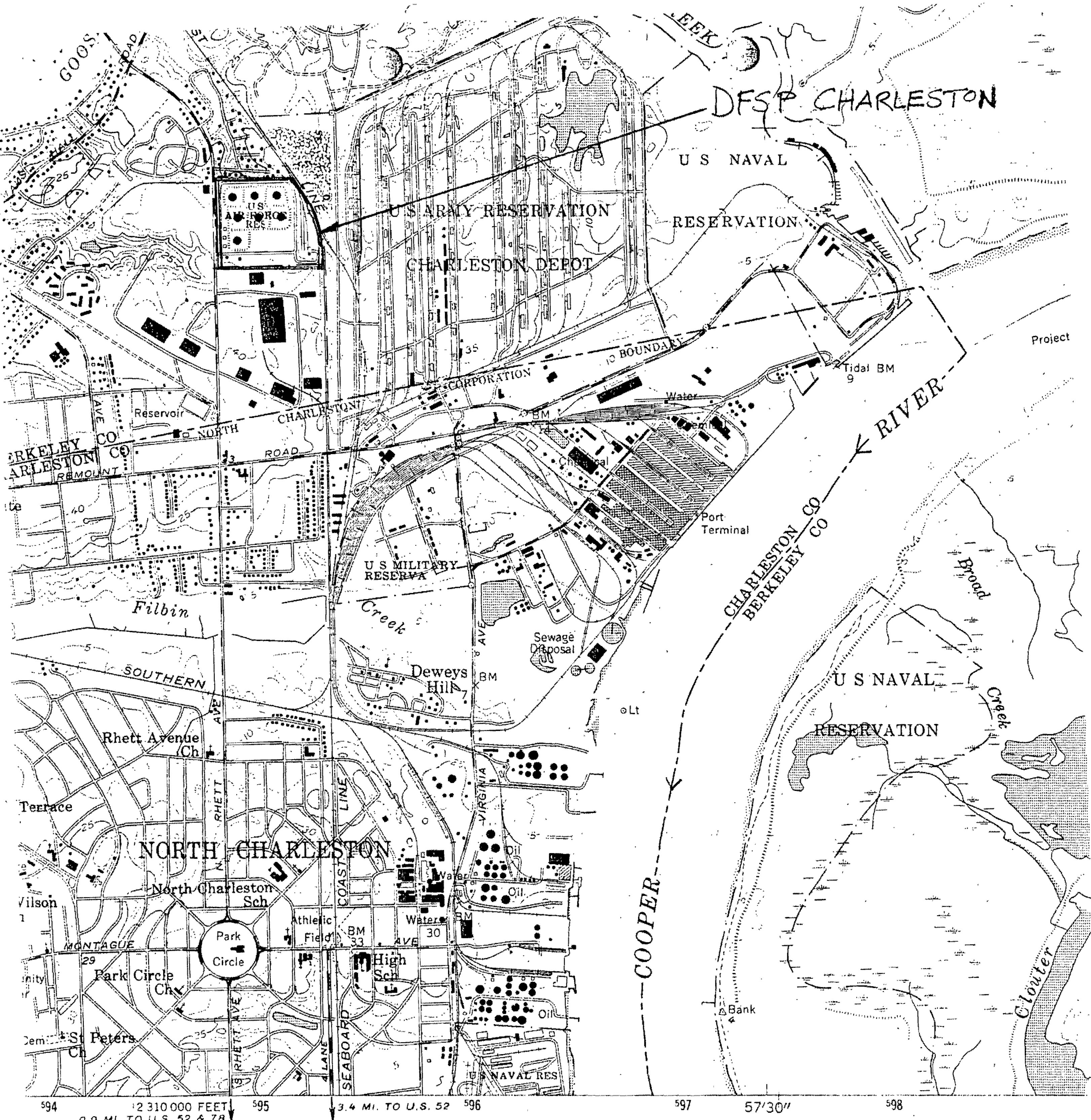


FIGURE 1. DFSP CHARLESTON GENERAL SITE MAP



DRAWN BY:	APPROVED BY:	PROJ. NO.	TITLE:
CHECKED BY:	DATE:	FIGURE NO. 1	SITE LOCATION MAP
RMT INC.		11 Regency Hills Drive P.O. Box 16776 Greenville, S.C. 29606 (803) 292-1921	SCALE: 1" = 2000'



dited, and published by the Geological Survey

GS, USC&GS, and South Carolina Geodetic Survey

rainage in part compiled from aerial photographs
Topography by planetable surveys 1958

compiled from USC&GS charts 470 (1957) and

ection. 1927 North American datum
rid based on South Carolina coordinate system,

Jniversal Transverse Mercator grid ticks,
vn in blue
e predicted North American Datum 1983
ction lines 15 meters south and

MN GN
3½°
62 MILS
0°35'
10 MILS

UTM GRID AND 1979 MAGNETIC NORTH
DECLINATION AT CENTER OF SHEET

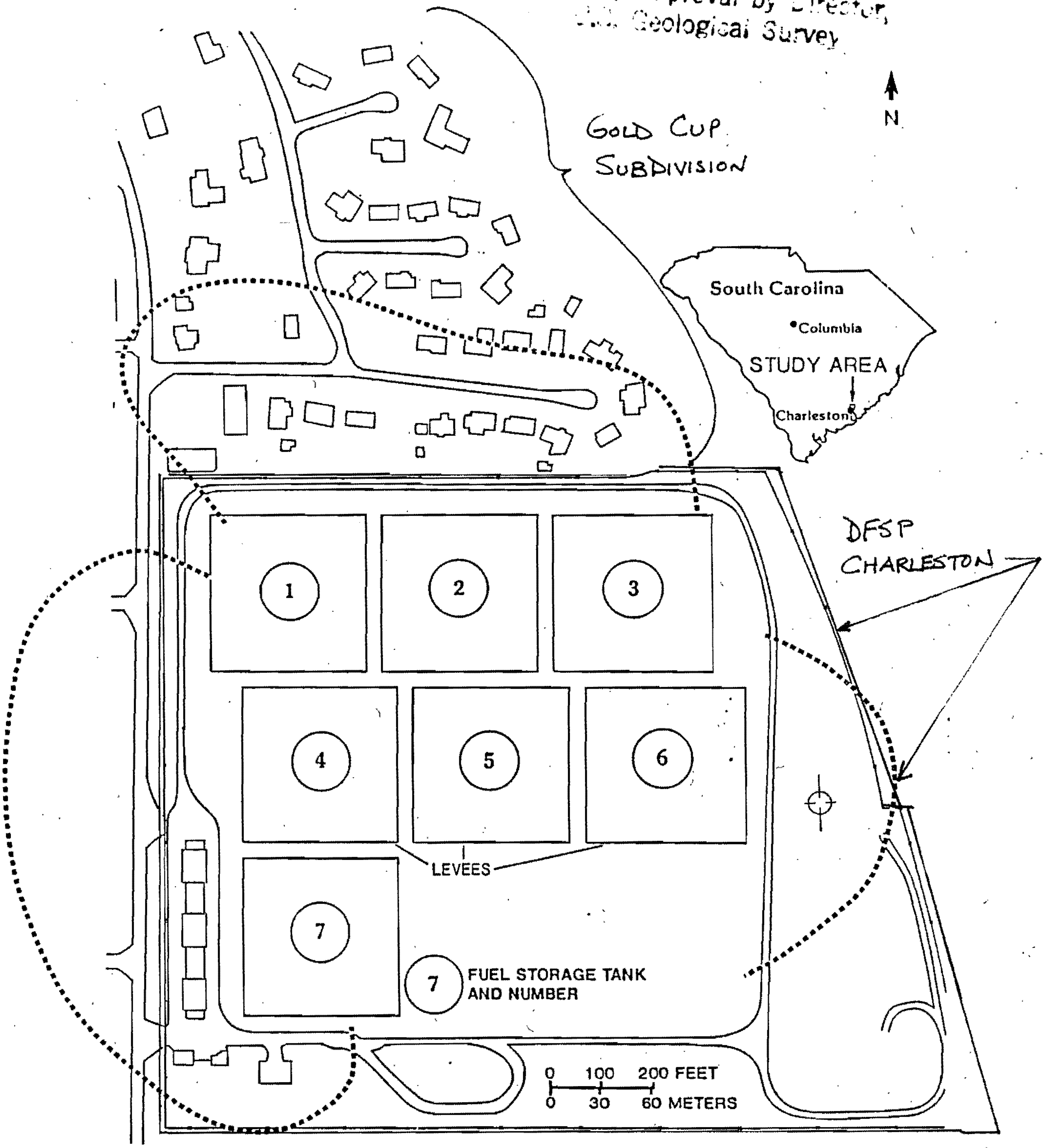
Fine red dashed lines indicate selected fence and field lines where

1 ½
1000 0 1000
1 .5

CO
NATIONAL

DEPTH CURVES AND S
THE RELATION
SHORELINE SHOWN REP
THE AVERAGE

USGS TOPO MAP



•••••••• Approximate lateral extent of contamination

Figure 1.--Approximate lateral extent of contamination of all known plumes at the DFSP facility, November 1989 (RMT,Inc.,1990).

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IV
345 COURTLAND STREET, N.E.
ATLANTA, GEORGIA 30365

SEP 13 1991

WD-RCRAFF

Certified Mail
Return Receipt Requested

Manager
Defense Fuel Supply Point Charleston
5862 N. Rhett Avenue
Hanahan, SC 29406

Re: Site Inspection Information for Revised Hazard Ranking System

Dear Sir:

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), requires the U.S. Environmental Protection Agency (EPA) to establish a Federal Agency Hazardous Waste Compliance Docket to provide information on the status and compliance of Federal Facilities that may have releases of hazardous substances. Section 120 specifically addresses federal agency compliance with requirements on response actions, site evaluations, and hazard ranking procedures for facilities on the Docket. Your facility is on the Docket.

EPA Region IV is currently contacting each federal facility on the Docket not currently on the National Priorities List (NPL) to request updated information under the revised Hazard Ranking System (HRS2) of the National Contingency Plan (NCP), which became effective March 14, 1991. Our records indicate that a Site Inspection (SI) report or its equivalent was submitted previously for your facility and we are writing to request an amendment or revision to provide the information needed.

Based upon information presented in the SI or equivalent report submitted earlier, your facility did not warrant placement on the NPL under the previous Hazard Ranking System (HRS1). However, under the revised scoring system, environmental impacts and human health hazards must be defined more fully, and the revised system may now qualify additional facilities for the NPL. Enclosed are guidance on HRS2 developed by EPA Region IV and the latest (1988) EPA guidance on SI.

We are requesting submittal of a revised SI report or an amendment within 60 days of receipt of this letter. If that is not feasible, we request submittal of a timetable for compliance within 30 days of receipt of this letter. You may include your preliminary calculations of a score under HRS2; however, EPA is responsible for the formal calculation of the ranking score.

If you have questions regarding the updating of SI information, please contact Mr. J. C. Meredith of this office at (404) 347-3016.

Sincerely yours,

James H. Scarbrough, P.E., Chief
RCRA & Federal Facilities Branch
Waste Management Division

Enclosure

cc: Mr. Hartsill Truesdale, Chief
Bureau of Solid and Hazardous Waste Management
South Carolina Department of Health
and Environmental Control

P 839 858 430

Certified Mail Receipt
No Insurance Coverage Provided
Do not use for International Mail
(See Reverse)

UNITED STATES POSTAL SERVICE

Sent to	Manager Defense Fuel Supply [illegible]
Street & No.	5862 N Rhett Avenue
P.O., State & ZIP Code	Hanahan, SC 29406
Postage	$
Certified Fee	
Special Delivery Fee	
Restricted Delivery Fee	
Return Receipt Showing to Whom & Date Delivered	
Return Receipt Showing to Whom, Date, & Address of Delivery	
TOTAL Postage & Fees	$
Postmark or Date	

PS Form 3800, June 1990

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 4
ATLANTA FEDERAL CENTER
100 ALABAMA STREET, S.W.
ATLANTA, GEORGIA 30303-3104

OCT 0 9 1997

4WD-RCRA

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

Donald Matthews, Department of Defense, Federal Liaison
Defense Fuel Support Point Charleston
5862 N. Rhett Avenue
Hanahan, South Carolina 29406

SUBJ: Compliance Evaluation Inspection
July 23, 1997
EPA ID No. SC9 570 024 332

Dear Mr. Matthews:

On July 23, 1997, the United States Environmental Protection Agency (EPA) conducted a Compliance Evaluation Inspection (CEI) at your facility located in Hanahan, South Carolina in order to determine it's compliance status with the Resource Conservation and Recovery Act (RCRA).

Enclosed is the EPA CEI Inspection Report which indicates that violations of RCRA were discovered. A copy of this report has also been forwarded to the South Carolina Department of Health and Environmental Control (DHEC).

If you have any questions, please contact Christi S. Ulmer, of my staff, at (404) 562-8578.

Sincerely yours,

S. Maher

Shannon Maher, Acting Chief
North Enforcement & Compliance Section
Enforcement & Compliance Branch

Enclosure

cc: DHEC-Charleston Field Office-Bill Seaborn (w/enclosure)

RCRA COMPLIANCE EVALUATION INSPECTION REPORT

A. Inspector and Author of Report

Christi S. Ulmer
Technical Specialist

Waste Management Division
North Enforcement Section
61 Forsyth Street, S.W.
Atlanta, Georgia 30303-8909
(404) 562-8578

B. Facility Information

Defense Fuel Support Point Charleston
5862 N. Rhett Avenue
Hanahan, South Carolina 29406

EPA ID No. SC9 570 024 332

C. Responsible Official

Mr. Larry Verhosek, Terminal Superintendent
(803) 744-3884

D. Inspection Participants

Larry Verhosek, Terminal Superintendent-Defense Fuel Support Point Charleston (hereinafter Defense Fuel)
Christi Ulmer, Technical Specialist- U.S. Environmental Protection Agency (EPA)
Bill Seaborn, Inspector-South Carolina Department of Health and Environmental Control (DHEC)
John Cooper, Inspector/Supervisor-DHEC

E. Date of Inspection

July 23, 1997

F. Applicable Regulations

40 Code of Federal Regulations (C.F.R.) Parts 260 - 265, 268, and 270; RCRA Section 3005 and 3007; and the South Carolina Hazardous Waste Management Regulations.

G. Purpose of Inspection

This inspection was a Compliance Evaluation Inspection (CEI) conducted by the South Carolina Department of Health and Environmental Control (DHEC) with the United States Environmental Protection Agency (EPA) to determine the facility's compliance with the Resource Conservation and Recovery Act (RCRA).

H. Facility Description

Defense Fuel is a federal facility located in Hanahan, South Carolina. It is a bulk petroleum facility which stores jet fuel in support of regional Department of Defense Air Bases. This facility contains a total of seven tanks and three loading racks. Five of the tanks contain JP8 and two contain JP5. Hazardous wastes generated at this facility include, almost exclusively, tank bottoms resulting from tank clean outs. Defense Fuel is registered with the State of South Carolina as a large quantity generator of hazardous waste.

I. Findings

This inspection included a tour of the tank farm and the loading racks.

1. The Tank Farm

There are no external floating roofs on the tanks in the tank farm. Subsequently, rainwater does not enter the tanks through the top. At the time of the inspection, contractors were working on-site to install a concrete foundation under two of the tanks and within the diked area. Eventually, all tanks at this facility will be located on concrete foundations. Tanks bottoms, generated during the infrequent tank clean outs, are analyzed to determine if they are hazardous waste prior to being shipped off-site. Water which accumulates at the bottom of the storage tanks is transferred to the oil/water separator. The oil is sent off-site to World Recovery Systems (WRS) for product recovery.

2. The Loading Rack

Jet fuel is transferred into tanker trucks for transport at the 2 loading racks in the front of the facility and into rail cars at the third loading rack located at the back of the facility. Any product or storm water that collects on the pad of the loading racks goes to an oil/water separator. The oil is from the oil/water separator is shipped off-site to WRS for product recovery and the water is shipped off-site. Analytical results reveal that the water is usually non-hazardous waste water. Water which accumulates within the berms of the tank farm is discharged under an NPDES permit to a waterway which is open for a short distance and then closed to the point where it discharges into the sewer destined for the POTW. Loading rack sumps are occasionally cleaned out. Defense Fuel makes a hazardous waste determination on the sump sludge using laboratory analyses before shipping it off-site.

3. Record Review

The facility's hazardous waste records were reviewed including the Quarterly Reports, Contingency Plan, Personnel Training and Manifests. The following record keeping violations were noted:

At the time of the inspection, Defense Fuel did not have the South Carolina 1st quarter (1997) and 3rd quarter (1996) reports available on-site.

> Defense Fuel failed to maintain a copy of the quarterly reports on-site in violation of the requirements of **R.61-79.262.40(b) and R.61-79.262.41.**

Defense Fuel has a letter which was sent to the local authorities with EPCRA information. However, they do not have a copy of a cover letter indicating the transmission of the Contingency Plan to local authorities.

> Defense Fuel failed to provide local authorities with a copy of the Contingency Plan in violation of the requirements of **40 C.F.R. § 265.53** and **R.61-79.265.53.**

Facility personnel were following a U.S. Department of Defense guidance document which indicated that they need training pursuant to **40 C.F.R. § 265.16** only once every three years. Accordingly, all of the facility personnel were out of compliance with the requirement for annual refresher training.

> Defense Fuel failed to provide employees with an annual review of the initial personnel training in violation of the requirements of **40 C.F.R. § 265.16** and **R.61-79.265.16(c).**

No hazardous waste was shipped off-site from this facility in 1996. One shipment of hazardous waste was sent off-site in 1997. There was no Land Disposal Restriction (LDR) certification form attached to this manifest.

> Defense Fuel failed to provide notification to the hazardous waste treatment facility that the manifested waste is land disposal restricted (LDR) waste in violation of the requirements of **40 C.F.R. § 268.7** and **R.61-79.268.7.**

J. Conclusions

The following violations of State and Federal RCRA regulations were found:

1. South Carolina Quarterly Reports: **R.61-79.262.40(b) and R.61-79.262.41.**

2. Contingency Plan: **40 C.F.R. § 265.53** and **R.61-79.265.53.**

3. Personnel Training: **40 C.F.R. § 265.16** and **R.61-79.265.16(c).**

4. Land Disposal Restriction: **40 C.F.R. § 268.7** and **R.61-79.268.7.**

K. Signed

Christi S. Ulmer | 10/3/97

Christi S. Ulmer
Technical Specialist

Date

L. Concurrence

Shannon Maher | 10/6/97

Shannon Maher, Acting Chief
Chief, North Compliance Section

Date

RMT INC.

11 Regency Hills Drive
P. O. Box 16778
Greenville, SC 29606
Phone: 803-292-1921

FINAL REPORT
REMEDIAL ALTERNATIVES REPORT
DEFENSE FUEL SUPPLY POINT
CHARLESTON, SOUTH CAROLINA

Prepared for:

DEFENSE FUEL SUPPLY CENTER
Mr. W. E. Goode
Chief, Environmental Quality Division
Directorate of Facilities Management

Prepared by:

RMT, Inc.
P.O. Box 16778
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CONTRACT NO. N62467-87-C-0027

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Dr. Larry Schutts, Hydrogeologist
February, 1988

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EXECUTIVE SUMMARY

The Defense Fuel Supply Point (DFSP) Charleston, and the Gold Cup Springs Lake Subdivision are located on North Rhett Blvd., in Hanahan, South Carolina. The DFSP is a bulk storage facility for JP-4 jet fuel used primarily by the Air Force. In 1975, a leak was discovered in the bottom of Tank 1 and an estimated 83,000 gallons of JP-4 were lost. Since 1975, there have been several remedial actions taken to recover the lost product and several field investigations to access the impact of the release to the DFSP site and the adjacent residential subdivision. As a result of the fuel spill, there is concern as to the potential residential exposure in the site vicinity to organic vapors. The Defense Logistics Agency and the Naval Facilities Engineering Command retained RMT, Incorporated to evaluate remedial alternatives that would be applicable to remove the organic constituents from the ground water and soils on the DFSP site and in the Gold Cup Springs Lake Subdivision.

In December, 1987, RMT, Inc. concluded the Aquifer Evaluation Report which defined the characteristics of the aquifer and verified the potential for air stripping of the organic compounds in the soils. Results from the field investigations conducted for the Aquifer Evaluation Report were used to model the ground water flow on the DFSP site and the adjacent subdivision.

The modelling of the local ground water flow was necessary to predict the effects of various remediation control strategies. The procedure involved calibrating the model by generating a water table surface. This was accomplished by varying hydraulic conductivity, total water recharge, and system flow boundaries, within physically reasonable limits. The final model matched the surface to approximately a foot. Having thus established basic flow characteristics, the effects of three pumping schemes were modeled. Wells were, in turn, placed around the BTEX plume, situated along the northern facility boundary and concentrated within the plume. Modest pumping rates intercept much of the ground water flowing from the facility and create significant water table depressions within the plume.

For a design basis in evaluating the groundwater treatment alternatives the highest observed well production rate was multiplied by the maximum number of wells needed in the groundwater flow model to contain the organic plumes. This resulted in a design flow of 200 gpm. A total BTEX concentration of 3 ppm was also used for design because it was among the highest values observed during the previously conducted well sampling.

The recommended control strategy for remediation of the DFSP site and subdivision is a groundwater extraction system consisting of a series of wells located along the northern boundary of the DFSP property to minimize further migration of BTEX constituents from the site. In addition wells will be located within the existing BTEX plume to remove groundwater from the subdivision for treatment. A vacuum extraction system for soil remediation is also recommended in conjunction with the extraction well system. If treatment of the groundwater is required, air stripping is recommended as the most applicable technology. The body and appendices of this report provide discussions and cost estimates of the aforementioned discharge and treatment recommendations with additional discussions and cost estimates of alternate treatments and discharges.

1. INTRODUCTION

1.1 Background

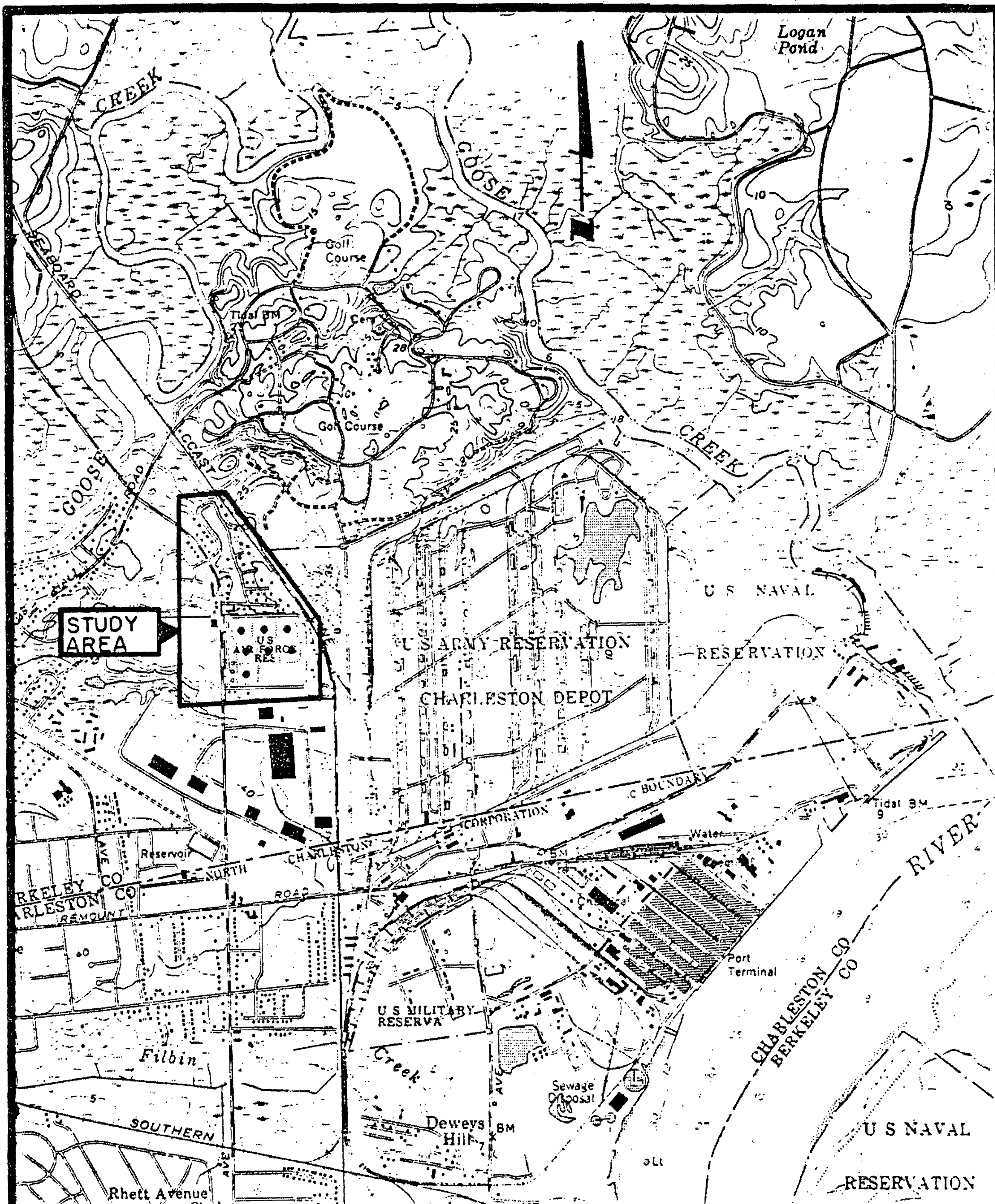
The Defense Fuel Supply Point (DFSP) Charleston is located within the city limits of Hanahan, South Carolina, and just off North Rhett Boulevard. Immediately adjacent north of the DFSP facility is a residential community called Gold Cup Lake Subdivision. The areas to the west and south include light industry. Figure 1 shows the site location.

The fuel terminal contains seven aboveground storage tanks. The tanks are 83,000 bbls (40-ft height, 120-ft diameter), welded steel with floating roofs and each is surrounded by an earthen dike. The primary fuel currently handled at DFSP Charleston is JP-4.

In 1975, a leak was discovered in one of the seven tanks that resulted in a release of an estimated 83,000 gallons of JP-4 fuel. Following the release of the fuel, several remedial actions were undertaken to recover the lost product and wells have been installed both on DFSP property and in the adjacent neighborhood (Gold Cup Lake Subdivision) to monitor ground water quality. JP-4 fuel and the specific compounds benzene, toluene, ethylbenzene and xylene have been identified in some of the off-site wells.

In a previous investigation at the DFSP site in 1982, Dames and Moore concluded that they found no evidence of significant quantities of jet fuel (JP-4) on the surface of the surrounding aquifer. They did find evidence of the 1975 jet fuel release from Tank 1 and recommended continued operation of the existing 36" recovery well near Tank 1. They also recommended that

From USGS Map North Cnarleston Area



DRAWN BY:	APPROVED BY:	PROJ. NO.	TITLE:
CHECKED BY:	DATE:	FIGURE NO. 1	SITE LOCATION MAP
RMT INC.		11 Regency Hills Drive P.O. Box 16778 Greenville, S.C. 29606 (803) 292-1921	SCALE: 1" = 2000'

additional clean-up efforts would be ineffective and that, with time, natural biological chemical and physical activities would remove the residual organics.

In another investigation of the DFSP site in 1986-87, McClelland Engineers, Inc. installed additional monitoring wells off-site. Sampling of the new and existing wells detected JP-4 related constituents (benzene, toluene, ethylbenzene and xylene) on both the DFSP site and in the adjacent residential subdivision (Figure 2).

In August 1987, RMT, Inc. was awarded two contracts to do an aquifer evaluation and remedial alternative report with respect to the DFSP site. Sampling conducted during the aquifer evaluation detected JP-4 constituents (benzene, toluene, ethylbenzene and xylene) in ground water beneath the DFSP site as well as in the adjacent residential area. This report contains the results of the remedial alternatives report and has had significant input from the previous RMT aquifer evaluation report.

1.2 Objectives

The purpose of this report is to investigate alternatives that will contain and remove the JP-4 related organic constituents in the ground water. The report is also to recommend the alternative(s) that will be most applicable for remediation of the DFSP site.

2. ALTERNATIVES FOR SITE REMEDIAL ACTION

2.1 Hydrodynamic Isolation and Control

2.1.1 Description of Possible Control Strategies

There are two control technologies - three physical barriers and hydraulic barriers - that are available to isolate the existing organic plumes at the DFSP site. Some of the physical containment structures include slurry cutoff walls, grout curtains and sheet pile cutoff walls. Ground water extraction wells or trenches can also form hydraulic barriers to flow.

Slurry walls are constructed in a vertical trench that is excavated under a slurry mixture. The slurry is usually a soil or cement, bentonite, and water mixture that is pumped into the trench as excavation proceeds. The slurry is used primarily to prevent the trench from collapsing during excavation and after it has set to act as a barrier to ground water movement.

Grout curtains are formed by injecting grout (Portland cement, bentonite, or alkali silicates) into the ground through well points in an overlapping pattern. The grout barriers are generally more costly than slurry walls and have been incapable of forming reliable barriers in medium sands.[6]

Sheet pile cutoff walls are made of wood, pre-cast concrete, or steel. The walls are constructed by driving web sections of sheet piling permanently into the ground with a drop hammer or a vibratory

Sheet pile cutoff walls are made of wood, pre-cast concrete, or steel. The walls are constructed by driving web sections of sheet piling permanently into the ground with a drop hammer or a vibratory hammer to act as a barrier to ground water flow. Each of the sections are interlocked at the edges and are assembled before being driven into the ground. The joints that interlock the sections are not water tight initially but they fill and seal with fine grained soil particles. Sheet pile cutoff walls are predominately used in loosely packed sand and gravel soils.

An extraction well system uses pumps to transport ground water to the surface for treatment and discharge. The system forms a cone of depression as the ground water table is lowered and is used to contain or remove a plume of contamination. To design a well system an aquifer model of the particular site is developed to estimate the required pumping rates required to contain or remove the plume.

Collection trenches can also be used to collect ground water. Pumping ground water from the trench creates a draw down that prevents or minimizes the flow of ground water past the trench. Trench depths are normally limited to less than 15 feet below the water table. If the soils are not predominately clay dewatering is often required to prevent wall collapse.

2.1.2 Discussion of Hydrodynamic Isolation and Control Strategy

An important aspect of aquifer remediation is the isolation of the affected zone and the reduction of the down gradient migration of the plume. Isolation techniques include physical containment structures (e.g., grout curtains or slurry cut-off walls) and hydrodynamic isolation systems. Often, the most cost-effective approach for hydrodynamic isolation and control is accomplished by ground water interception and withdrawal, treatment, and recharge.

Hydrodynamic isolation produces a closed system within which a discrete zone of ground water is isolated and recirculated from withdrawal wells and/or trenches to recharge wells and/or trenches. Once flow patterns have stabilized after system implementation, the withdrawal system will be pumping only ground water that has been previously withdrawn, treated, and recharged. Figure 3 presents a typical hydrodynamic isolation system. From Figure 3, it is apparent that hydrodynamic isolation influences regional ground water flow patterns. A line of stagnation, or ground water divide, is formed around which the regional flow lines diverge.

Advantages of hydrodynamic isolation and control include operational flexibility, ease of construction, and high reliability. Hydrodynamic isolation systems require on-going system maintenance and verification monitoring.

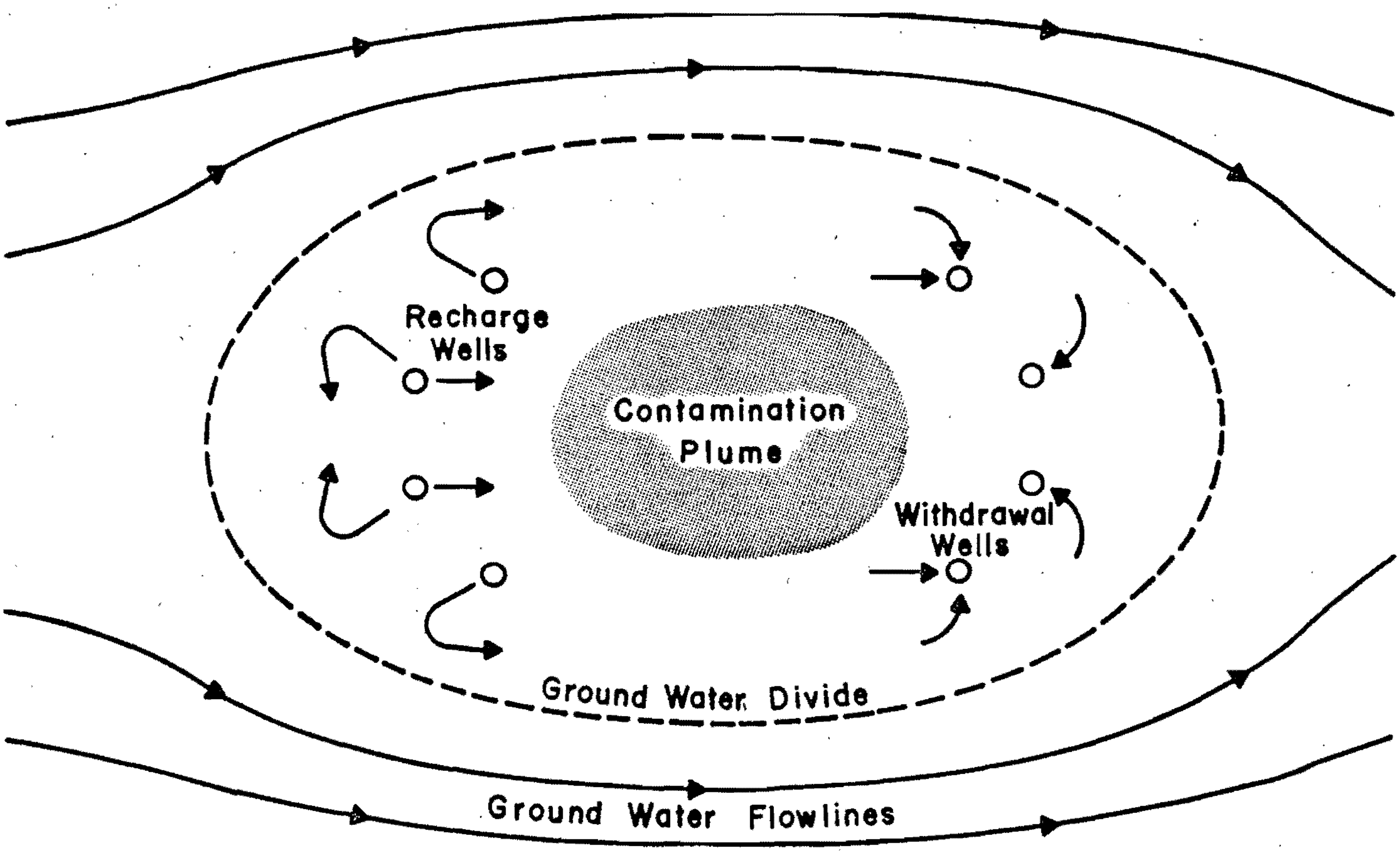


FIGURE 3

HYDRODYNAMIC CONTROL /

WITHDRAWAL RECHARGE SYSTEM

2.1.3 Development and Documentation of Ground Water Flow Model

The region of primary interest is that portion of the Gold Cup Springs Lake Subdivision underlain by the BTEX plume (Figure 4). Ground water flow was modeled in an area centered on the highest BTEX concentrations. The first step involved trend surface analysis of ground water elevations. Fourteen data sets were available. The most complete was based on recent measurements by RMT (Table 1). Each of the others was calculated from values provided by Dames & Moore (1982). It was necessary to revise the Dames & Moore data, in order to reflect recently determined riser pipe elevations (Table 2). In all fourteen cases, third order trend surfaces were found to be most representative of the water tables considered. The Dames & Moore data, while spatially restricted to the DFSP facility, provided valuable insights into seasonal variability of ground water levels. The more regionally-based RMT values anchored levels in the subdivision. Examination of the various surfaces supported exclusive use of the RMT data, in determining a representative, time-average water table. Successive water table models were adjusted in such a way that Table 1 values were approached.

The McDonald and Harbaugh (1984) three-dimensional computer flow model was used for this project. As required by the model, the region was divided into rectangular map cells. Computations produced a single water level, for each cell. Grid axes were oriented E-W (50 foot increment) and N-S (100 foot increment). It was assumed that flow is restricted to the highly permeable materials overlying the Oligocene

TABLE 1

WATER TABLE ELEVATIONS
DURING THE PERIOD 11/17/87 - 11/20/87

WELL NO.	RISER ELEVATION (Ft. MSL)	DEPTH TO WATER (Ft.)	WATER TABLE ELEVATION (Ft. MSL)	ELEVATION OF SCREEN INTERVAL (Ft. MSL)
W-103	36.66	14.94	21.72	30.2 - 0.2
W-104	37.43	15.22	22.21	30.9 - 0.9
W-105	39.14	16.02	23.12	32.6 - 2.6
W-106	38.64	13.60	25.04	32.1 - 2.1
W-107	37.57	10.62	26.95	31.1 - 1.1
W-108	37.68	10.36	27.32	31.2 - 1.2
B-101	40.09	12.83	27.26	33.6 - 3.6
B-103	43.52	13.30	30.22	37.0 - 7.0
W-1	16.96	0.95	16.01	***
W-2	16.37	7.81	8.56	***
W-3	31.93	15.93	16.00	***
MW-4	27.90	10.85	17.05	21.7 - 1.7
MW-5	20.11	2.72	17.39	9.1 - 0.0
MW-7	38.63	12.44	26.19	34.0 - 24.0
MW-8	12.16	0.05	12.11	1.1 - <8.9>
MW-9	9.16	1.07	8.09	6.0 - <4.0>
MW-10	6.25	1.07	5.18	5.8 - <4.2>
MW-11	37.47	14.59	22.88	33.1 - 18.5
MW-11A	37.30	15.46	21.84	9.1 - 4.5
MW-12	37.85	11.52	26.33	28.8 - 18.8
MW-12A	37.80	11.42	26.38	9.3 - 4.3
MW-13	31.31	9.78	21.53	26.6 - 16.6
MW-15	13.15	2.63	10.52	8.6 - 0.0
MW-16	28.16	3.22	24.94	22.9 - 12.9
MW-17	36.61	9.59	27.02	29.3 - 19.3

Well locations are illustrated in Figure 2.
Riser Elevations were measured by Southeastern Surveying, Inc.
Water Table Elevation = Top of Riser Elevation - Depth of Water Below Top of Riser

* Information not available.

TABLE 2

REVISED DAMES & MOORE WATER TABLE ELEVATIONS

Well	W-101	W-102	W-103	W-104	W-105	W-106	W-107	W-108	B-101	B-102	B-103	B-104	B-105	B-106	B-108	B-109
Riser Elevation	34.48	34.06	36.66	37.43	39.14	38.64	37.57	37.68	40.09	42.87	43.52	36.35	37.08	41.82	38.08	41.53
11-28-81	18.68	17.98	19.60	21.04	22.45	23.42	26.17	26.58	25.80	30.12	29.53	30.37	31.66	30.97	28.02	29.48
12-02-81	18.48	18.31	19.99	21.35	23.16	23.76	ND	26.68	26.15	31.47	30.14	30.57	29.17	30.59	28.03	29.63
12-07-81	18.46	18.28	19.93	20.30	23.07	23.67	ND	26.65	26.25	30.49	29.60	30.12	29.31	30.67	28.12	29.71
01-06-82	17.81	19.71	20.16	21.55	22.91	29.98	27.54	27.90	27.67	32.37	30.69	31.64	32.98	33.16	30.57	32.24
01-20-82	18.79	18.50	21.43	25.99	26.48	24.31	27.17	27.57	27.15	32.45	30.48	30.40	32.70	32.69	30.32	31.78
02-05-82	17.69	18.87	20.26	21.78	23.37	24.51	26.88	27.30	26.79	32.20	32.54	30.77	32.68	32.61	29.95	30.57
02-19-82	18.38	19.21	21.37	22.70	23.18	24.33	27.07	27.80	27.88	33.06	30.67	30.87	32.79	33.57	31.12	32.68
02-26-82	19.81	19.71	21.24	23.10	24.79	25.76	27.11	28.64	27.30	31.93	32.23	30.66	32.77	32.90	30.77	32.09
03-12-82	18.47	19.52	21.49	22.39	22.89	24.26	26.63	27.30	27.51	32.45	30.48	30.47	32.45	32.69	31.52	32.24
03-26-82	19.29	19.04	21.10	22.01	22.87	23.95	26.84	26.72	26.30	32.22	30.48	30.31	32.06	32.09	29.43	30.93
04-13-82	17.38	18.64	20.20	21.76	22.47	23.72	26.22	26.47	26.38	31.56	28.98	30.60	31.81	31.07	28.52	30.51
04-19-82	17.92	18.72	20.38	21.71	22.60	23.97	26.65	26.98	26.57	31.79	30.02	30.67	31.83	31.76	29.00	30.90
04-29-82	18.73	19.71	20.62	20.89	22.44	23.72	26.92	26.76	27.46	33.37	30.75	30.68	33.01	33.07	31.16	32.72

Original data in Dames & Moore (1982; Table 1).
All elevations are in feet above mean sea level.
Riser elevations were measured by Southeastern Surveying, Inc..
Well locations are illustrated in Figure 2.

ND = No Data

Cooper Formation (marl). This led to calculations based on a single-layer aquifer, the bottom of which is nearly flat-lying (Table 3).

During the course of modeling, boundary conditions, hydraulic conductivities and recharge rates were all varied. In addition, conductivity and recharge were subjected to sensitivity analysis. The southernmost row of grid blocks was assumed to represent a constant head boundary. With the exception of the extreme western end, flow passes into the system along the entire length of the strip. Water levels were prescribed on the basis of linear interpolation between readings from wells MW-7 and B-103. The lake, located in the northwest portion of the region, and the western end of the southern strip were taken to be constant head areas of outflow. The remaining boundaries were assumed to represent streamline or divide "no flow" barriers. An initial conductivity value of 15 inches per year, was based on McClelland (1987) estimates and on preliminary evaluation of recent RMT pump test data. Spatially variable final values (5-10 ft/day) were the result of model calibration modifications and more detailed analysis of the RMT pump tests. Data provided by the U.S. Geological Survey (Columbia, SC) led to an initial recharge estimate of 15 inches per year. Model calibration, more detailed analysis of local conditions and the assumption of leakage to a lower aquifer resulted in spatially variable final values for this parameter as well (0-5 in/yr).

The final, pre-remediation ground water model is illustrated in Figure 6. The average deviation from Table 1 elevations is 1.1

TABLE 3

PARAMETERS ASSOCIATED WITH THICKNESS OF THE
SINGLE-LAYER MODELING AQUIFER

WELL NO.	GROUND SURFACE ELEVATION	TOP OF COOPER MARL ELEV.	AQUIFER THICKNESS (ft.)
W-101	34.6	-0.1*	34.7
W-102	36.3	2.3*	34.0
W-103	35.5	-1.5*	37.0
W-104	35.2	0.2*	35.0
W-105	36.7	-0.3*	37.0
W-106	36.4	-2.1*	38.5
W-107	35.2	-1.8*	37.0
W-108	35.2	0.4*	34.8
B-101	38.4	2.4*	36.0
B-102	40.3	4.6*	35.7
B-103	41.1	2.1*	39.0
B-104	33.4	0.9*	32.5
B-105	35.0	0.5*	34.5
B-106	39.2	4.7*	34.5
B-108	36.2	3.7*	32.5
B-109	38.9	4.4*	34.5
MW-8	12.5	-2.0+	14.5
MW-9	9.1	-0.9+	10.0
MW-10	6.5	-3.5+	10.0
MW-11A	35.6	1.6!	34.0
MW-12A	35.8	0.8!	35.0

* Dames & Moore (1982)
\+ McClelland (1987)
! RMT (1988)

Well locations are illustrated in Figure 2
All elevations are in feet above mean sea level.
Ground surface elevations were measured by Southeastern Surveying Inc.

feet. Steady-state flow lines radiate from the DFSP facility, pass through the subdivision and converge on the lake.

2.1.4 Results of Imposing Selected Control Strategies Upon Ground Water Flow Model

The effects of three remediation pumping schemes are illustrated in Figures 7-9. Each scheme exhibits a distinct well distribution and different pumping rates. Characteristics are listed in Table 4. Calculations assumed Figure 6 starting conditions and a fully screened aquifer. Again, methods outlined by McDonald and Harbaugh (1984) were followed. In order to approximate steady-state conditions, the pumping period was set at one year. Illustrated well positions represent grid cell centers. Since individual cell computations yield single water levels, well positions can be translated up to 25 feet E-W and 50 feet N-S, without altering Figure 7-9 contours. System flow rates are given in Table 5.

In pumping Scheme 1, wells surround the leading edge of the BTEX plume. In response to the wells paralleling Valley Street, southern contours have been rotated to a more nearly E-W position. Essentially, these wells partially intercept the natural ground water flow. The six northernmost wells have created a depression. Except for defined constant head areas, water levels fall significantly below pre-pumping values. Losses of saturated thickness are as high as 67%. Total fluids removed from the system amount to about 39,000 gallons per day.

TABLE 4

CHARACTERISTICS OF THE REMEDIATION PUMPING SCHEMES
ILLUSTRATED IN FIGURES 7 - 9

Scheme Parameters	1	2	3
No. of Wells	18	15	24
Pumping Rate/Well (gal/min)	1.5	2.0	1.5
Total Pumping Rate (gal/day)	38880	43200	51840

TABLE 5

VOLUMETRIC BUDGET SUMMARY
FOR THE VARIOUS STEADY-STATE
GROUND WATER FLOW MODELS

	NON-PUMPING CASE	PUMPING SCHEME 1	PUMPING SCHEME 2	PUMPING SCHEME 3
	cubic feet per day			
INTO SYSTEM				
Constant Head	1498.9	3210.0	5044.7	2904.9
Recharge	2167.8	2167.8	2167.8	2167.8
Total	3666.7	5377.7	7212.4	5072.6
OUT OF SYSTEM				
Constant Head	3665.0	157.6	1437.9	701.9
Wells	0.0	5220.0	5775.0	4370.0
Total	3665.0	5377.6	7212.9	5071.9
IN - OUT	1.65	0.10	-0.50	0.72
PERCENT DISCREPANCY	0.05	0.00	-0.01	0.01

Scheme 2 features wells situated along the northern and northwestern tank farm boundaries. Most are located at the bottom edge of the hill, on which the facility rests. Four sit on the crest of the hill, inside the DFSP fence. Once again, southern contours have been rotated more nearly E-W. A string of local depressions parallels the northern edge of the facility and an interception effect is particularly well-developed. Saturated thickness losses run as high as 60%. The 33% higher pumping rate associated with this plan leads to removal of 11% more water (43,200 gal/day).

Scheme 3 involves pumping from within the body of the plume itself. Southern contours are rotated and pushed south to the same extent they were in Scheme 1. The same sort of northwestern plume area depression is exhibited. Maximum saturated thickness losses amount to about 80% of pre-pumping levels. The pumping rate removes nearly 52,000 gallons of fluid per day.

2.2 General Site Remediation Strategies

2.2.1 Ground Water Withdrawal, Treatment, and Discharge to Surface Water

In cases where ground water recharge is not possible due to regulatory prohibitions or limiting geologic conditions, such as low permeability, hydrodynamic control can be accomplished by ground water withdrawal only. Preliminary investigations at the DFSP site do not indicate any geological limitations to recharge.

In a scenario such as this, affected ground water is intercepted and withdrawn, pumped to a centralized treatment facility, and then discharged. A typical cross-section of such a facility is presented in Figure 10. Discharge would either be to an existing receiving stream (Goose Creek or to the Cooper River) and/or to the North Charleston Sewer District (NCSD) treatment system (identified as POTW in Figure 10). A NCSD sewer line would not be immediately available to DFSP.

Hydrodynamic control, using only ground water withdrawal, is controlled by the degree which the withdrawal system draws down the aquifer in the affected area and provides a gradient for the ground water to be conveyed into the withdrawal system. This approach is totally dependent on ground water drawn into the affected zone from outside the zone. Therefore, unaffected ground water is continually being exposed to constituents within the affected zone.

2.2.2 Ground Water Withdrawal, Treatment and Recharge

Hydrodynamic control by ground water withdrawal and recharge develops a mound (positive gradient) of water around the recharge wells and/or trenches. This promotes an increased transport of ground water through the aquifer which in turn helps to expedite the remediation effort by increasing the flow-through velocity.

Figure 11 presents a typical cross-section of a system where recharge is used in conjunction with ground water withdrawal. This

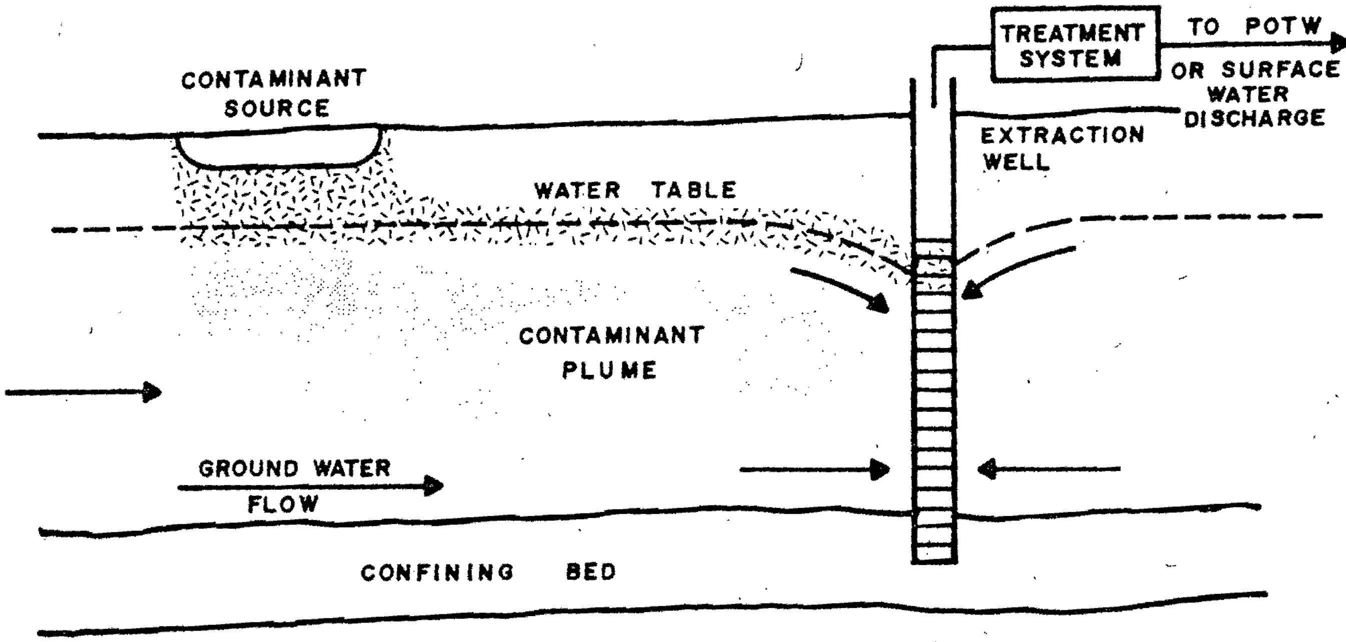


FIGURE 10

WITHDRAWAL AND TREATMENT SYSTEM

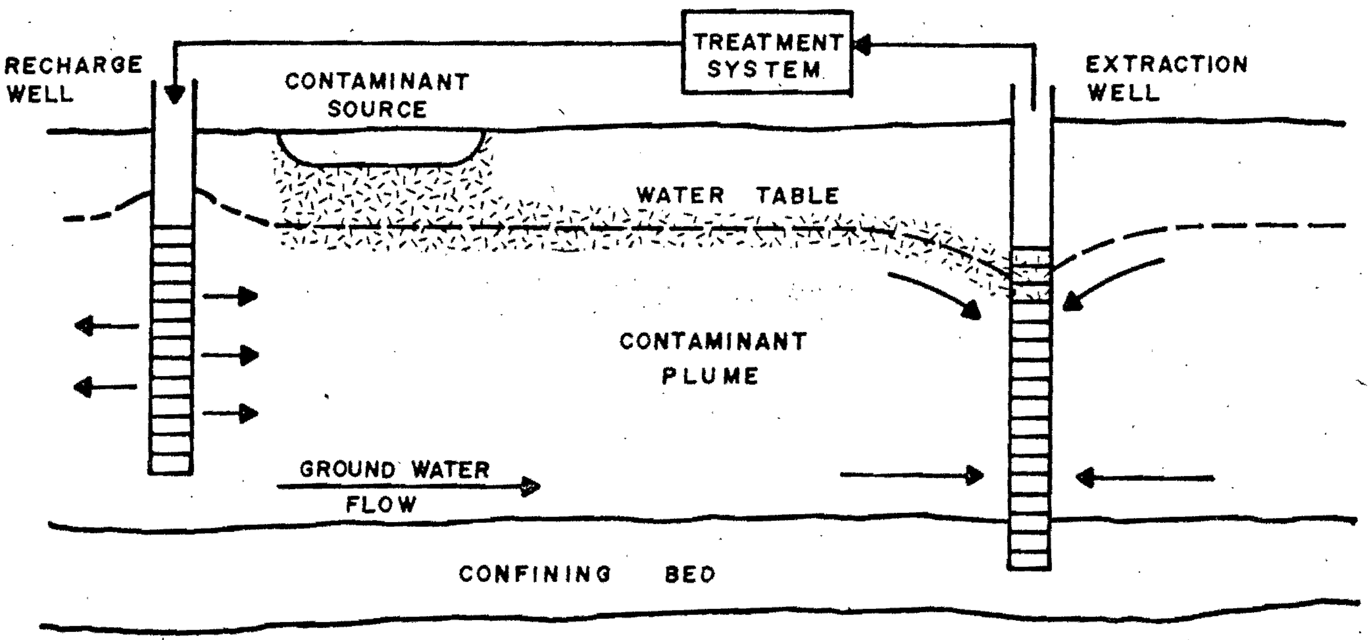


FIGURE II

WITHDRAWAL, TREATMENT, AND RECHARGE SYSTEM

RMT INC.

approach increases the rate at which an aquifer is flushed. As result, this approach would also be more effective in reducing the time required for complete remediation of the site.

Ground water recharge reduces the amount of water entering the affected zone of the aquifer. A strict withdrawal system is dependent on ground water drawn from outside the affected zone. A withdrawal-recharge system, however, constantly recirculates treated ground water creating a discrete zone of treatment. Filtration may be required to prevent clogging of the recharge system from suspended particulate matter developed in the treatment processes.

Additional potential advantages of a withdrawal recharge system is its ability to accommodate in-situ biological treatment (to be discussed in Section 2.2.4) and its ability to remediate unsaturated soils by flushing action.

2.2.3 Vacuum Extraction of Impacted Vadose Zone Soils

In-situ air stripping is rapidly evolving as a practical approach for removing volatile organic compounds from unsaturated soils. This approach is accomplished by applying a vacuum through one or more wells located above the water table which induces an air draft through the soils. Air is many times more permeable through soils than water and, as a result, can be more effective in removing volatile compounds from unsaturated soils than the flushing of the soils with groundwater. This approach could also be applied to soils dewatered by withdrawal wells during hydrodynamic control which is the subject of the previous section.

In-situ air stripping of dewatered and unsaturated soils should be considered, since most of the compounds present in the DFSP ground water have relatively high vapor pressures. Although many factors contribute to the applicability of in-situ air stripping the vapor pressure of an organic compound is an indicator of how readily that compound can be volatilized from soils. Laboratory testing has been performed to confirm the applicability of this approach (Appendix 4).

2.2.4 In-Situ Biological Remediation

In-situ biological remediation can be accomplished by the addition of appropriate nutrients to the recharge water which enhances the biodegradation potential of naturally-occurring micro-organisms. In-situ biological remediation has been used successfully on may organic compounds, including several present in the DFSP ground water. A typical cross-section of this approach is present in Figure 12.

Optimum nutrient requirements, primarily oxygen, nitrogen, phosphate, and trace compounds, are determined by laboratory evaluation in which a soil inoculum is treated at a number of nutrient concentrations. The purpose of these studies is to enhance the viability of the soil bacterial population. Laboratory determinations are then verified in the field.

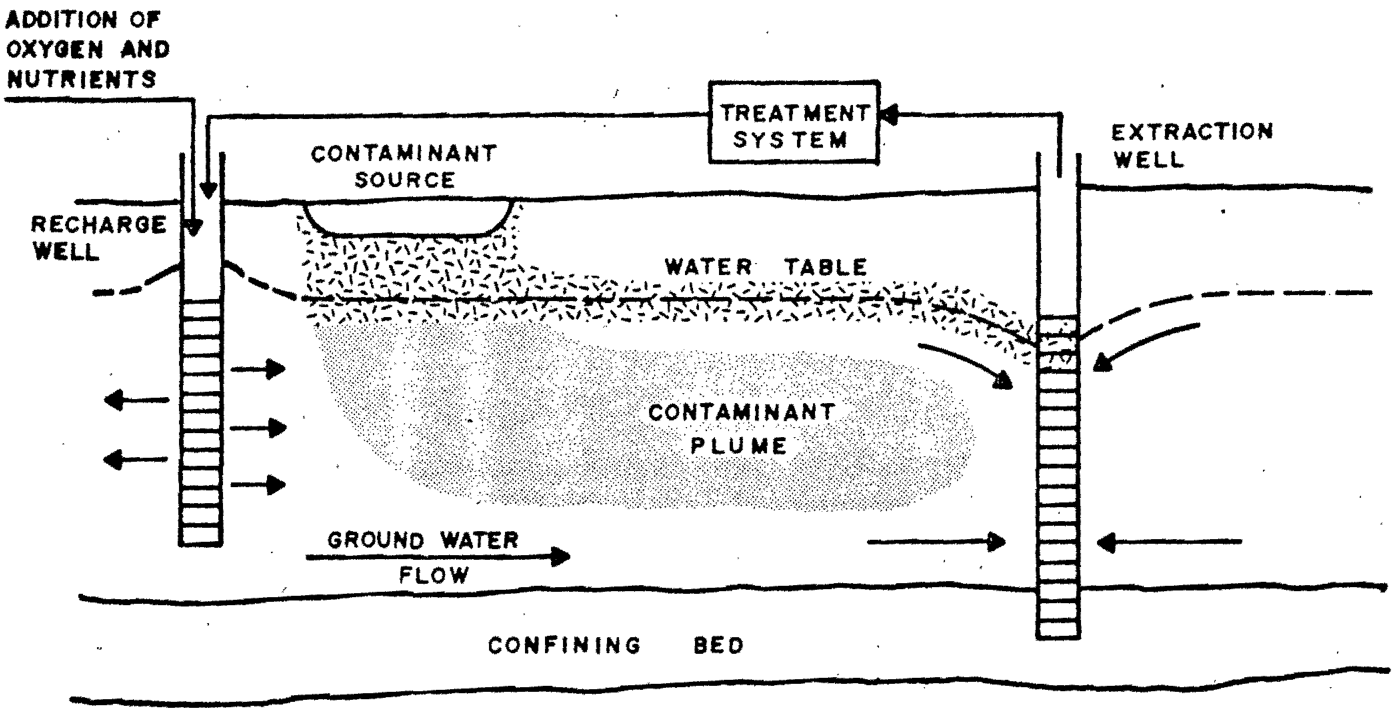


FIGURE 12

CROSS SECTION OF BIORECLAMATION SYSTEM

An in-situ biological remediation feasibility study is currently being conducted for the DFSP site by the US Geological Survey.

2.2.5 No Action

A no-action alternative should be considered after all hydrogeological and public health and safety investigations are completed. This alternative could apply to certain areas of the DFSP site, depending upon results from the in-situ biological treatment study.

2.2.6 Comprehensive Approach

Each of the approaches presented in Section 2.2 are appropriate solutions for the DFSP site conditions and should be carefully considered. All of the approaches have been successfully used at similar remedial action sites. It is possible that certain of these approaches are best applied to specific areas of the DFSP site, while other approaches are best utilized in other areas. The site remediation strategy should be based upon a comprehensive application of the technologies best suited for site specific needs.

2.3 Discussion of Unit Operations for Site Remediation

Four basic unit operations appear applicable for ground water and soil treatment at the DFSP site based on the physical characteristics of the organic compounds detected in the ground water.

2.3.1 Air Stripping

The Henry's Law constant for the organic compounds detected in the ground water (benzene, ethylbenzene, toluene and xylene) is greater than 1 x 10-3 atm·m3/mole; which indicate that these compounds are readily removed by air stripping. Air stripping could require a VOC emission control system, if air quality regulations dictate such a need.

2.3.2 Vacuum Extraction

Vacuum extraction, or in-situ air stripping, of volatile organics from soils will be considered since volatile organics are the primary constituents of the affected ground water. It is primarily applicable to unsaturated zone soils. The applicability of vacuum extraction at the DFSP site has been demonstrated in the laboratory (report - Appendix A).

Vacuum extraction may also be applicable to soils that will be dewatered by ground water pumping. This option is considered most applicable to areas where the organics are in high concentrations and have high Henry's Law constants. After a pumping well has established a cone of depression and previously saturated soils become dewatered, a portion of volatile organics may remain adsorbed to the dewatered soils. A vacuum can be applied directly to a ground water collection well such that the well simultaneously functions as a ground water collection well and as a vacuum extraction well inducing an air flow through the dewatered soils. This induced air flow strips the volatile organics from the soils. Organic levels in air emissions would have to be evaluated.

Applying a vacuum to a well can also increase the well's yield. RMT has witnessed this increase in one application and Terra Vac Corporation has demonstrated well yield enhancement at several other site applications.[9] The increased well yield appears to be the result of optimized well development and inducted pressure gradient resulting from vacuum application. Vacuum extraction will be considered for optimizing ground water collection for the hydrodynamic control system and any supplemental collection wells. The impact of vacuum extraction can be evaluated during the interim remedial action operations.

2.3.3 Biological Treatment

The organic compounds in the ground water at the DFSP site are readily biodegradable in the activated sludge process. The activated sludge process utilizes aeration, in most applications, to aid the waste assimilation. The ground water that would be generated during the remediation activity at DFSP alone would not sustain an activated sludge system. A local municipal wastewater treatment system could be utilized, but due to the lack of sufficient capacity and the logistics of transporting the ground water to the treatment facility biological treatment does not appear to be a viable alternative.

2.3.4 Activated Carbon Adsorption

Activated carbon adsorption of the aqueous phase is included as a treatment alternative and as a possible polishing treatment to the treated effluent of an air stripping system depending on the required surface discharge limits.

3. EVALUATION OF SITE REMEDIATION

3.1 Hydrodynamic Isolation and Control

The goal of containing and removing the organic plumes at the DFSP site requires the use of one or several of the described control strategies in section 2.1.1. At the DFSP site the installation of physical barriers along the site property boundary or in the residential neighborhood poses special problems. At the DFSP site along the northern property line there is not enough space to install physical barriers without disrupting the use of the facility. For this reason the use of extraction wells to contain the plumes was given the most consideration.

3.2 Groundwater Cleanup Levels

There is much uncertainty on the levels of ground water cleanup needed at this type site. The regulatory basis for requirements is evolving. Considering these factors, it is not possible to set a specific number for a specific material for the level of cleanup. Rather, the report is developed to set up a system to minimize the movement of materials in ground water and the use of the most practicable methods of cleaning up existing elevated levels. The cleanup strategy in this plan has been developed to be consistent with the development of cleanup levels by the regulatory agencies. A review was done on Records of Decisions (ROD's), which are the final determinations on the type of controls and levels of cleanup at "superfund" type sites. There was limited information available. Also, for the projects reviewed there were differences in the cleanup goals.

A review was done on the EPA regulations establishing various goals or levels for the materials of concern. These materials were benzene, ethylbenzene, toluene, and xylene. The drinking water levels with explanations are as follows:

- Benzene
  A Maximum Contaminant Level (MCL) of 0.005 mg/l has been promulgated.

- Ethylbenzene
  A Maximum Contaminant Level Goal (MCLG) of 0.68 mg/l has been proposed.

- Toluene
  A Maximum Contaminant Level Goal of 2.0 mg/l has been proposed.

- Xylene
  A maximum Contaminant Level Goal of 0.44 mg/l has been proposed.

RECENT DRINKING WATER REGULATIONS

MCL Maximum Contaminant Level (National Primary Drinking Water Regulations)
Enforceable standards set close to MCLGs, but also based on treatment feasibility, treatment costs, and analytical detection limits.

MCLG Maximum Contaminant Level Goal (Substituted for RMCL terminology).
Nonenforceable health goal which is set at the maximum level in drinking water at which no known or anticipated adverse effect on the health or persons would occur, and which allows an adequate margin of safety.

RMCL Recommended Maximum Contaminant Level (Replaced by MCLG terminology)
Nonenforceable health goal set at level which would result in no known adverse health effects with a margin of safety. RMCLs are set at zero for known or probable carcinogens. Chronic toxicity data and Acceptable Daily Intakes (ADI) are used to set RMCLs for other compounds. RMCLs published before June 19, 1986 are to be treated as MCLGs.

SMCL Secondary Maximum Contaminant Level (Secondary Drinking Water Regulations)
Nonenforceable federal guideline set at level requisite to protect public welfare effects.

3.3 Treatment Unit Operations

Choosing a particular treatment technology for a specific application depends on a number of factors. It must be established that the technologies being considered are applicable to the situation and then the economics usually become the prime interest. For situations of low flow and low concentration of organics the cost differential between carbon adsorption and air stripping is usually small enough that a decision could be based on availability and the ease of installation and operation.

Activated carbon adsorption is a highly developed treatment technology for removal of organics from aqueous waste streams. The highest concentration of organics that is usually considered for treatment in an aqueous stream is one percent or 10,000 ppm total organic carbon (TOC). At the DFSP site the highest average TOC concentration is well below this level. While an activated carbon adsorption system would remove the organics from the ground water it would also require regeneration of the spent carbon for reuse and disposal of the collected organics. Pretreatment would also be required of the influent to remove oil and grease and suspended solids. For these reasons the biggest limitation of the activated carbon process is the high capital and operating cost.

Air stripping of ground water to remove organic contaminates is another highly developed treatment technology. The stripping of volatile components from water is usually accomplished in a packed tower, a cross flow tower, a coke tray aerator, or a diffused air basin. The packed tower has the highest removal efficiencies and cost and the diffused air basin the lowest efficiencies and cost. An important factor when considering whether to utilize air stripping technology for the removal of organics is the air pollution generated from the process.

Air stripping has been used very cost-effectively in recent years, for treatment of low concentrations of volatiles or as a pretreatment prior to activated carbon adsorption.

4. RECOMMENDATIONS AND PRELIMINARY DESIGN BASIS FOR SITE REMEDIAL ACTIVITIES

4.1 Ground Water Extraction Well Network

A ground water extraction well network is recommended to limit the further movement and begin removal of the organic plume at the DFSP site. RMT also recommends that additional monitoring wells be installed to better define the edge of the BTEX plume before proceeding to final design.

The recommended remediation of the DFSP site and adjacent subdivision is a ground water extraction system consisting of a series of wells located along the northern boundary of the DFSP property to minimize further migration of BTEX constituents from the site. In addition, wells will be located within the existing BTEX plume to remove ground water from beneath the subdivision for treatment. This well system corresponds to pumping scheme 3 (Figure 9) and is discussed in section 2.1.4. Cost estimates for the system are in Table 7 with a more detailed breakdown in Appendix B.

4.2 Ground Water Treatment System(s)

A conservative design basis using 200 gpm of 3 ppm total BTEX organics was chosen for the cost estimates of the air stripping, carbon adsorption and combination air stripping/carbon adsorption treatment systems. The flowrate of 200 gpm was selected because it is the highest observed well production rate multiplied by the maximum number of wells needed in the ground water flow model to contain the organic plume.

The cost estimates for the three treatment systems are based on the cost curves in the API publication "Treatment Technology for Removal of Dissolved Gasoline Components from Ground Water". The curves were developed over a range of feed concentrations, hydraulic loadings, regeneration conditions (carbon adsorption), temperatures (air stripping), and air/water ratios (air stripping). Table 6 below summarizes the cost estimates (Appendix C) for the three treatment systems.

TABLE 6

Treatment System Cost Estimates

System	Treatment Costs/ 1000 gal +	Capital	Operating*
Activated Carbon Adsorption	($0.45)	($40,000)	($9,000/yr)
Air Stripping°	($0.85)	($72,000)	($10,800/yr)
Activated Carbon/ Air Stripping	($1.30)	($112,000)	($19,800)

* does not included labor costs
( ) 1983 dollars

\+ Treatment Costs is a composite of the operating costs plus 30% of the installed equipment cost to cover depreciation, maintenance, and overhead. The installed equipment cost is defined as 3.5 times the estimated equipment purchase cost.

° Air stripping costs were based on 99.9% removal of the organics from the ground water using a packed column. Lower removal requirements would decrease the treatment, capital, and operating costs.

4.3 Soil Vacuum Extraction System

The wells that comprise the ground water extraction network should be installed with the capability of accommodating a vacuum extraction system. A design basis for the vacuum extraction system using the extraction wells from option 3 was chosen for the cost estimates in Appendix D. Vacuum extraction offers the most practical approach for removing volatile organic compounds from the vadose zone soils. Estimates for installation of the piping and renting of the vacuum system for an 18 month period are $570,000.

4.4 Treated Effluent Discharge

The quantity of treated ground water from the air stripping or carbon adsorption (or combination) system is estimated as low 28,000 gpd for the option 1 control strategy and as high as 100,000 gpd for short term maximum pumping rates using 5 gpm from each well in the option 3 control strategy. As a design basis for discharge to Goose Creek or the Cooper River, and for the cost estimates, a flow of 200,000 gpd was used to provide addition capacity in the future.

It is RMT's recommendation to negotiate with North Charleston Sewer for discharge. If flows during remediation remain low enough for the sewer system to accept it should be easier and less expensive than building a pipe line to either Goose Creek or the Cooper River. If a pipe line is to be built to the Cooper River or to Goose Creek it would cost approximately $225,000 and $150,000 respectively (Appendix E). To compare the advantages of discharge to Goose Creek vs the Cooper River, any additional treatment requirements by DHEC should be considered.

4.5 Air Emissions

Air emissions generated from air stripping of the extracted ground water would be approximately 7 pounds per day of organics (Appendix F) based on the stripping of 200 gpm of ground water with 3,000 ppb of total organics. Sources this small are reported, in writing, to DHEC but do not usually require a formal permit application. The use of vacuum extraction in the remediation of the DFSP site could provide another source of organic emissions that should also be reported to DHEC.

TABLE 7

SUMMARY OF ESTIMATED REMEDIATION COSTS

SYSTEM	CAPITAL COSTS
Ground Water Extraction Well Network	$325,000
Ground Water Treatment Systems	
Carbon Adsorption	$40,000
Air Stripping	$72,000
Carbon Adsorption/ Air Stripping	$112,000
Soil Vacuum Extraction System For 18 Months	$570,000
Effluent Discharge	
To Cooper River	$225,000
To Goose Creek	$150,000
To North Charleston Sewer	Not Available

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3. McClelland Engineers, 1987, Confirmation Study Characterization Step; Defense Fuel Support Point, Charleston, South Carolina.

4. "Treatment Technology for Removal of Dissolved Gasoline Components From Ground Water", prepared for American Petroleum Institute by IT Enviroscience, May 1983.

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7. Sims, Ronald et al. 1986. Contaminated Surface Soils In-Place Treatment Techniques. Noyes Data Corporation, Park Ridge, NJ.

8. Ehrenfeld, John and Bass, Jeffrey, 1984. Evaluation of Remedial Action Unit Operations at Hazardous Waste Disposal Sites. Noyes Data Corporation, Park Ridge, NJ.

9. Terra Vac Incorporated. 4923 West Waters Ave., Tampa, Florida 33614 (813)885-5374. Contact Jim Malot.

Appendix A

Vacuum Extraction Report

**LABORATORY VACUUM EXTRACTION
OF JET FUEL CONTAMINATED SOIL
FROM THE DFSD - CHARLESTON SITE**

Prepared for:

RMT Greenville

Robert R. Stanforth

Robert R. Stanforth
Applied Chemist

606.02:RTC:dfsd1224

TABLE OF CONTENTS

1. INTRODUCTION

Soil at the Defense Fuel Supply Depot in Charleston, South Carolina has been contaminated with jet fuel #4. One remediation technology being considered for the contaminated soil in the unsaturated zone is vacuum extraction. During vacuum extraction, a vacuum is placed on the contaminated soil, withdrawing the pore gas and drawing fresh air through the soil. As the air passes through the soil, organic contaminants in the soil volatilize into the moving air stream and are removed from the soil.

To evaluate the applicability of vacuum extraction technology to the DFSD site, a laboratory demonstration of the behavior of site soil during vacuum extraction was conducted. The purpose of the demonstration was to determine whether or not the soil could be remediated by vacuum extraction technology. To this end a sample of contaminated soil from the site was placed in a metal tube through which air was drawn using a vacuum pump. The extraction was continued until analysis of the soil indicated that the contamination was substantially removed from the soil. Both the exhaust gas and soil were sampled during the extraction to determine the change in concentration of contaminant in both media. Soil content was measured using a headspace method.

Note that the method demonstrates qualitatively the effectiveness of vacuum extraction. Soil conditions are too complex to be accurately modelled in the laboratory. Quantitive extrapolation of laboratory results to field conditions is very difficult.

2. LABORATORY METHODS

One hundred fifty grams of site soil (sample MW-12A, 9-10.5) was placed in a 1.8-inch diameter steel shelby tube. Clean sand was used to fill the rest of the tube. A subsample of soil was taken for headspace analysis, as described below. The tube was sealed at both ends with one-hole rubber stoppers. To one end of the tube a vacuum pump was attached, with a 1 liter vacuum flask between the tube and the vacuum pump. The flask was used for sampling (for the HNU meter) and as protection for the pump. A flow meter and flow adjustor were attached to the other end of the tube. At the exhaust end of the tube, holes in the shelby tube were covered with plastic tape through which samples for GC analysis were taken in a syringe. A stone frit was placed in the tube above the holes to provide an air space in the tube from which samples could be taken.

Air flow rate was initially set at 0.2 L/min. After one day (1665 minutes) extraction time the flow rate was increased to 1 L/min. and the extraction continued until the soil appeared to be clean. During a second run a flow rate of 1 L/min was used. Both flow rates are in the estimated range of air flow rates that might be found in soil a few feet away from a vacuum extraction well.

The exhaust gas was analyzed using a Photovac model 10S50 gas chromotograph. Gas samples were taken from the exhaust end of the shelby tube with a gas-tight syringe and injected directly into the gas chromatograph. Soil samples were analyzed by placing approximately 10 grams of soil in a 40 ml VOA vial with a septum top. The soil and air in the vial were allowed to sit for 30 minutes or longer so that the organics in the soil would approach equilibrium with the gas phase, then a sample of the headspace taken with a gas-tight syringe and analyzed on the gas chromatograph.

Selected peaks were chosen from the chromatogram of the unextracted soil to represent the soil contamination (Figure 1). These peaks were used to quantify the amount of jet fuel found in either the exhaust gas or the soil headspace. Benzene, toluene, and xylene standards were run; however the three compounds were not present in high enough concentrations to give major peaks on the chromatograph and so were not quantitified. This is not to say that they were not present, just that they formed a small portion of the total and so were difficult to separate from the compounds present in much larger quantities. Exhaust gas concentrations are reported as peak area (in volt-sec), while the soil headspace results are presented as a percentage of the unextracted soil headspace concentration.

3. RESULTS

3.1 Overall Results

Vacuum extraction removed the jet fuel contamination from the soil within 36 to 48 hours extraction time in the laboratory apparatus. Results of the two test runs are presented in Tables 1 and 2. Prior to extraction the soil was wet, smelled of petroleum products, and left an oil residue on any glass it contacted. After extraction the soil was dry, had no odor, and did not leave a residue on glass. Soil headspace readings of the soil indicated jet fuel concentrations below detection in the soil. Therefore it appears that vacuum extraction was successful at remediating the soil in the laboratory system used. Vacuum extraction would appear to be a potentially viable remediation method for the vadose zone soil at the site.

3.2 Soil Headspace Concentrations

Soil headspace results are presented in Figure 2. There is a clear decrease in soil headspace with extraction volume. After one to two days extraction times (or after approximately 2,400 liters) the soil headspace concentrations were below detection. Results from both runs fell near the same line. Some variability in results was found, most likely because of sampling errors. As the soil is remediated, the portion closest to the air inlet is remediated first, while the interior soil takes a longer time to be remediated. If the soil is not well mixed when a sample is taken, somewhat inconsistent results may occur. Since mixing the soil enhances volatilization, which is to be avoided except during vacuum extraction, only moderate mixing was done during sampling. Hence, some sample heterogeneity undoubtedly occured. Also, replicate sampling of the contaminated soil indicates that the soil itself is heterogeneous - headspace concentrations varied as much as 50% between replicates of the uncontaminated soil. Despite variability caused by sample or sampling heterogeneity, the overall trend of a decrease in soil headspace concentration with extraction volume is clear.

3.3 Soil Gas - HNU Concentrations

Organic concentrations in the extracted gas were measured with a HNU meter and with a field GC. The HNU readings are more extensive, and somewhat easier to interpret, and will be used in the discussion. The HNU readings show a sharp decrease initially, when plotted against extraction volume followed by a rise then slower fall to values below detection (Figure 3). Both runs had the concentration rise in the middle of the extraction, suggesting that the rise is a real phenomenon, at least in the laboratory experiments. A possible explanation for the rise in exhaust concentration midway through the extraction may be that the removal of jet fuel from the soil is slowed by the presence of water in the soil. After the soil starts to dry out jet fuel concentration in the exhaust gas increases. Measured initial concentrations of jet fuel in the exhaust gas throughout the experiment were relatively low in comparison with some other solvents RMT has worked with for vacuum extraction, e.g., mineral spirits. The lower initial concentrations may be a result of water in the soil, and did not appear to greatly affect the overall vacuum extraction effectiveness.

4. SUMMARY

A laboratory vacuum extraction set up successfully removed jet fuel contamination from DFSD soil within a reasonably short time (36 - 48 hours). The results indicate that vacuum extraction is a possible remediation techncology for the site.

Table 1
DSFS - Jet Fuel Contaminated Soil
Laboratory Vacuum Extraction
Test Run #1

150 g soil, flow rate initially 0.2 L/min increase to 1 L/min after 1665 min. extraction time

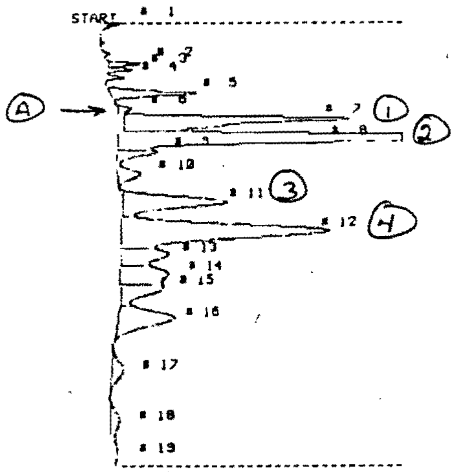
Extraction Time Min	Volume Extracted L	Exhaust Gas HNU ppm	Exhaust Gas GL V-sec	Soil Headspace % Initial Valve Percent
0	0			100
5	1	6.0		
20	4	5.8		
30	6	5.3	21.5	
60	12		10.5	61
120	24	1.0	7.5	33
240	48	1.0	11.5	69
405	81	1.0	8.0	
700	140	0.9	20.5	44
1450	290	0.7	7.5	
1575	315	0.6	14.6	
1605	321	0.6	34.6	
1665	333	1.0		
1695	363	1.7	38.1	
1725	393	1.9	32.6	
1785	453	1.6	21.4	
1815	483	1.4	19.1	
2760	1428	0.2		
2790	1458	0.05	<1.0	0

Table 2
DSFS - Jet Fuel Contaminated Soil
Laboratory Vacuum Extraction
Test Run #2

150 g soil, flow rate 1 L/min

Extraction Time Min	Volume Extracted L	Exhaust Gas HNU ppm	Exhaust Gas GL V-sec	Soil Headspace % Initial Valve Percent
0				100
5	5	3.0		
10	10	2.7		
15	15	2.3		
30	30	1.3		
65	65	0.8		
105	105	0.9		
155	155	0.9		
220	220	1.1	2.8	
260	260	1.4		
330	330	1.7	7.7	13
365	365	1.6		
1445	1445	1.7	8.7	9
1535	1535	1.3		
1655	1655	1.0		
1790	1790	0.8		
1955	1955	0.3		
2140	2140	0.3		
2165	2165	0.2		
2195	2195	0.1		
2240	2240	0	<0.1	<0.1

PHOTOVAC



STOP @ 1750.0
SAMPLE RUN DEC 10 [illegible]
ANALYSIS # [illegible]
TEMPERATURE [illegible]
GAIN 2 [illegible]

COMPOUND NAME	PEAK	R.T.	AREA/PPM
C-DCE	2	164.5	4.964 PPM
UNKNOWN	3	186.9	1.0 VS
UNKNOWN	4	210.3	678.9 mVS
UNKNOWN	5	283.7	6.1 VS
UNKNOWN	6	349.3	1.2 VS
TCE	7	393.7	33.24 PPM
UNKNOWN	8	466.8	154.2 VS
UNKNOWN	9	527.0	4.4 VS
UNKNOWN	10	614.0	3.3 VS
UNKNOWN	11	721.9	17.6 VS
UNKNOWN	12	837.7	43.8 VS
UNKNOWN	13	930.4	8.4 VS
UNKNOWN	14	1006.7	10.0 VS
UNKNOWN	15	1059.7	7.7 VS
UNKNOWN	16	1181.6	13.5 VS
UNKNOWN	17	1391.5	2.9 VS
UNKNOWN	18	1593.9	2.6 VS

Figure 1 - Gas chromatograph of headspace of unextracted soil from DSFD site. 1, 2, 3, and 4 are peaks used in quantifying headspace and exhaust has concentrations. A is the approximate location of a benzene peak under the chromatographic conditions.

FIGURE 2

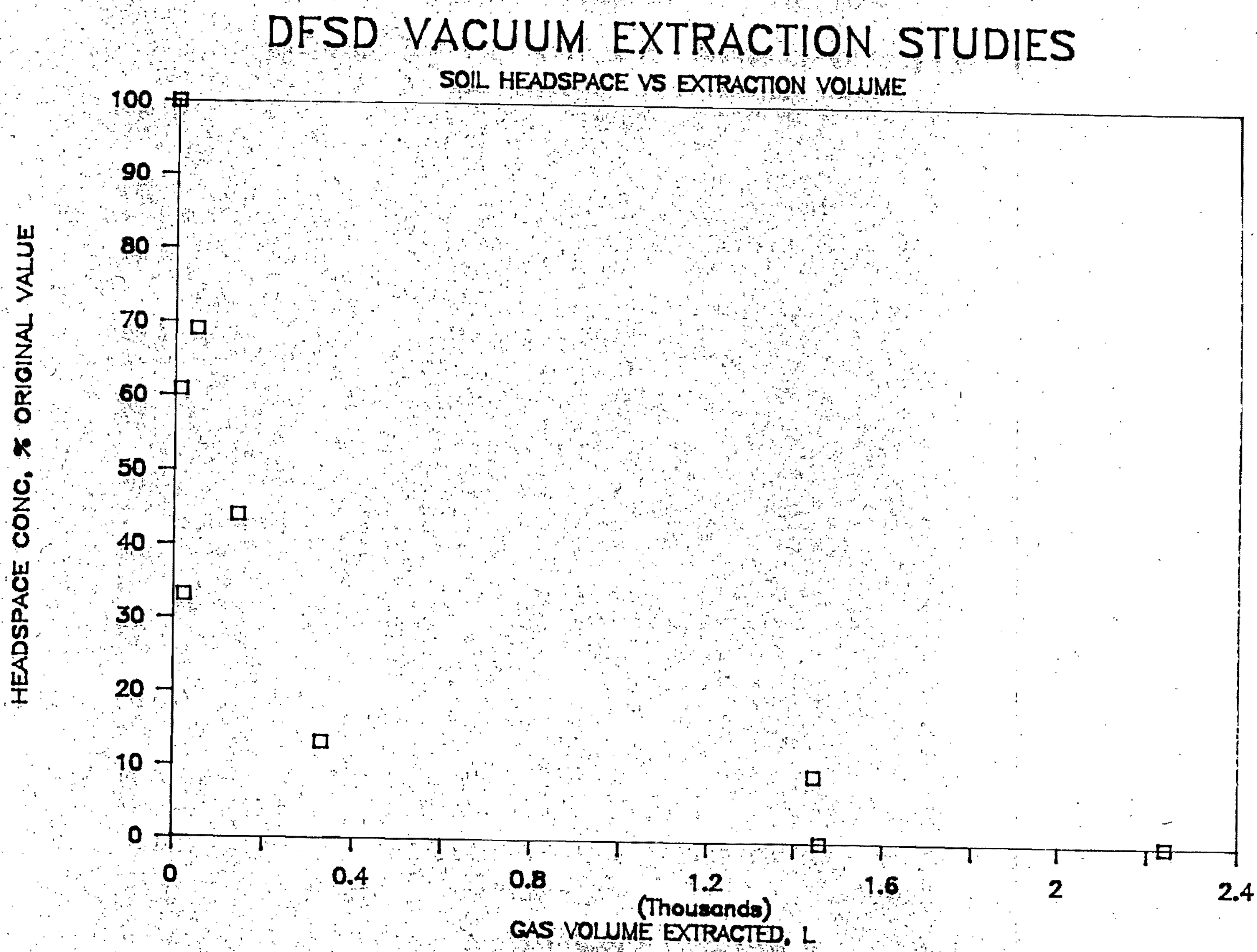
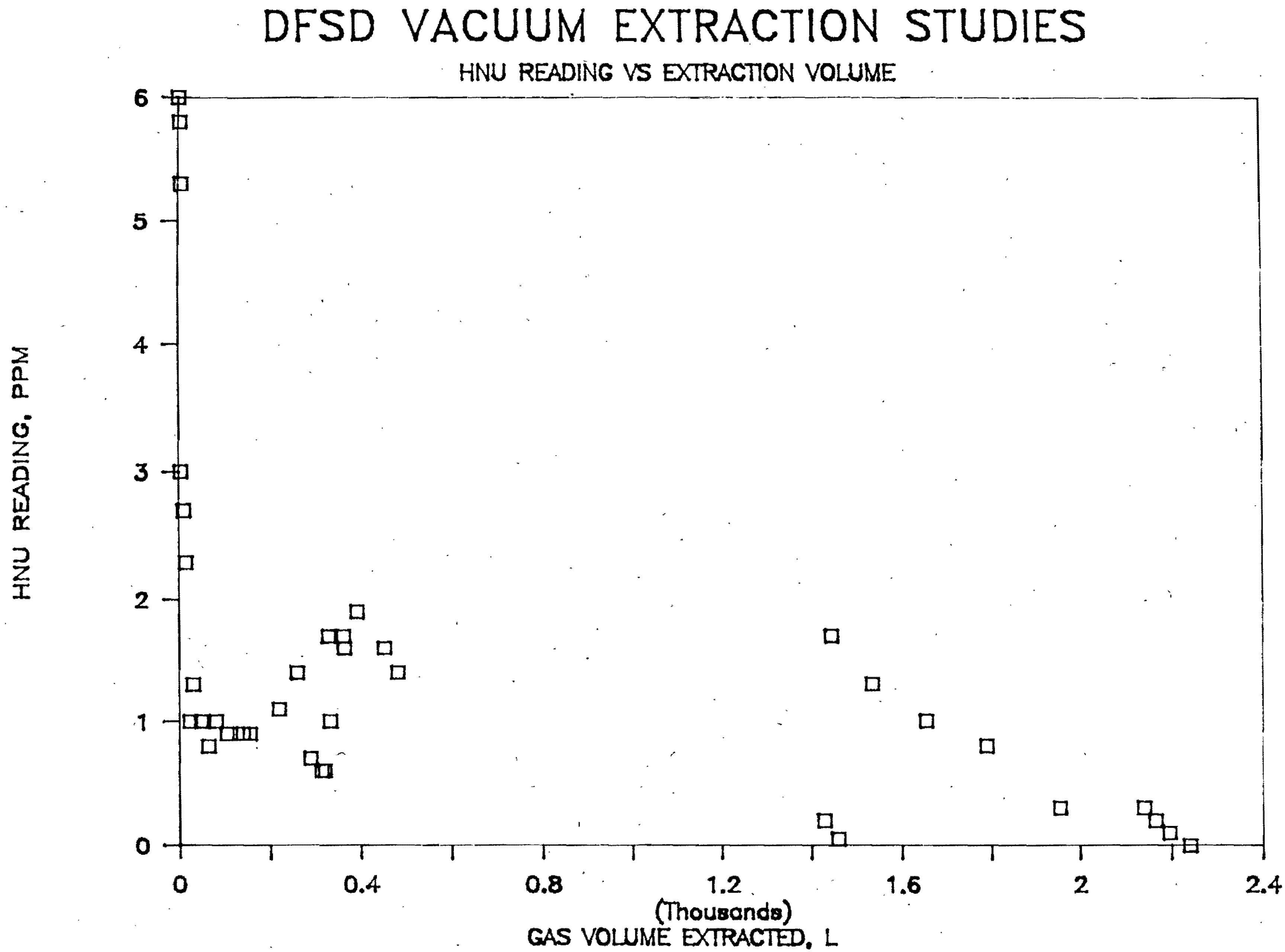

DFSD VACUUM EXTRACTION STUDIES
SOIL HEADSPACE VS EXTRACTION VOLUME
HEADSPACE CONC, % ORIGINAL VALUE
100
90
80
70
60
50
40
30
20
10
0
0
0.4
0.8
1.2
1.6
2
2.4
(Thousands)
GAS VOLUME EXTRACTED, L

FIGURE 3



DFSD VACUUM EXTRACTION STUDIES
HNU READING VS EXTRACTION VOLUME
HNU READING, PPM
0
1
2
3
4
5
6
0
0.4
0.8
1.2
1.6
2
2.4
(Thousands)
GAS VOLUME EXTRACTED, L

Appendix B

Extraction Well Network Cost Estimates

RMT INC.

11 Regency Hills Drive, P.O. Box 16778 Greenville, S.C. 29606 (803) 292-1921

DESIGN SHEET

SHEET ______ OF ______

PROJECT / PROPOSAL NAME	PREPARED By:	Date:	CHECKED By:	Date:	PROJECT/PROPOSAL NO.
Cost of Well Installation					

Based on option or scheme # three which contained 24 pumping wells.

Wells

2 6" Ø wells, 40' deep, pump, pitless adapter, piping/wiring in well, mobilization, installation $99,600

24 @ 3500 = $84000

[illegible] 24 @ 650 = $15,600

Control Panels $83,400

24 @ 3300 = $79,200

installation 24 @ 175 = $4,200

Piping Assuming above ground is used

3,650 ft of various size pipe @ 15/ft ≈ 55,000 installed $55,000

Electrical

Assume equivalent to similar projects

24 @ 500 per well $12,000 $12,000

	sub total	$250,000
contingency	15%	37,500
engineering	15%	37,500
		$325,000

$325,000 assumes above ground piping etc.

Appendix C

Treatment System Cost Estimates

RMIT INC.
11 Regency Hills Drive, P.O. Box 16778 Greenville, S.C. 29606 (803) 292-1921

DESIGN SHEET

SHEET ____ OF ____

PROJECT / PROPOSAL NAME	PREPARED By:	Date:	CHECKED By:	Date:	PROJECT/PROPOSAL NO.

Treatment costs for 1) carbon adsorption
2) air stripping, and
3) activated carbon/air stripping
were taken directly from the following API report. The dollars are in 1983 dollars.

TREATMENT TECHNOLOGY FOR REMOVAL OF DISSOLVED GASOLINE COMPONENTS FROM GROUND WATER

FINAL REPORT

VOLUME TWO

Submitted To

American Petroleum Institute
Washington, DC

Prepared By

IT Enviroscience
Knoxville, Tennessee

May 13, 1983

CONTENTS

I. INTRODUCTION

The API desired an evaluation of options for treating ground water containing dissolved gasoline components. In particular, the API was concerned about aromatics such as benzene, toluene, xylene, and ethylbenzene, and oxygenates such as t-butyl alcohol (TBA) and methyl-t-butyl ether (MTBE). These components are referred to in the report as total organic of interest (TOI). In an earlier literature search and evaluation,[1] activated carbon adsorption and air stripping (or a combination of these technologies) were identified as the most likely treatment alternatives. Land application was also identified as an alternative for certain applications. The API contracted with ITE to conduct a technical and economic evaluation of the alternative technologies.

A laboratory evaluation of the adsorption and stripping technologies was conducted in order to identify optimum design conditions. Activated carbon adsorption was evaluated over a range of feed concentrations, hydraulic loadings, and regeneration conditions (the carbon was nondestructively regenerated with steam). Air stripping was evaluated over a range of feed concentrations, temperatures, and air/water ratios. Volume One of this report details the experimental procedures and results.

Based on design and operating conditions identified in the laboratory evaluations, capital and operating cost estimates for full-scale systems were developed. Cost curves were generated over the range of design and operating conditions.

The cost curves in this report are intended to be used as a treatment manual to aid in selecting the appropriate treatment technology for a particular application.

II. EVALUATION OF PROCESS ALTERNATIVES

A. ACTIVATED CARBON ADSORPTION

1. Process Description

Activated carbon adsorption has drawn widespread consideration as a technology for treating contaminated ground water. There are three basic ways in which the technology can be implemented.

Using activated carbon on a throwaway basis is a good way to ensure good effluent quality. Virgin carbon is capable of removing gasoline components from ground water to low parts per billion levels. Carbon replacement costs can become very high, however, and disposal of the contaminated carbon can be a problem.

Activated carbon adsorption with thermal regeneration can be an alternative to throwaway carbon. Most ground water applications do not result in a high enough carbon consumption to justify on-site thermal regeneration, thereby necessitating the use of a regeneration service. The cost of a thermal regeneration service may approach the cost of purchasing virgin carbon.

The most cost-effective use of activated carbon adsorption utilizes nondestructive regeneration techniques.[2,3,4] Based on the experimental results, steam regeneration appears applicable for regeneration of activated carbon used to adsorb gasoline components from ground water. A basic flow sheet of the steam regeneration process is shown in Fig. 1.

With the proper design, steam regeneration can be accomplished in the adsorber, drastically reducing carbon handling losses. The nondestructive nature of the process lends itself to recovery of the organics if desired, but even if recovery is not desirable, disposal requirements are reduced from several thousand pounds of contaminated carbon to approximately fifty gallons of organic material.

Although IT Enviroscience had demonstrated the nondestructive regeneration technologies in process applications, concern had existed about the ability to achieve the low effluent concentrations required in ground water applications. The experimental portion of this project demonstrated that activated carbon adsorption with steam regeneration is a viable treatment alternative for removing dissolved gasoline components from ground water. Utilizing 10 lb

STEAM REGENERATION FLOWSHEET

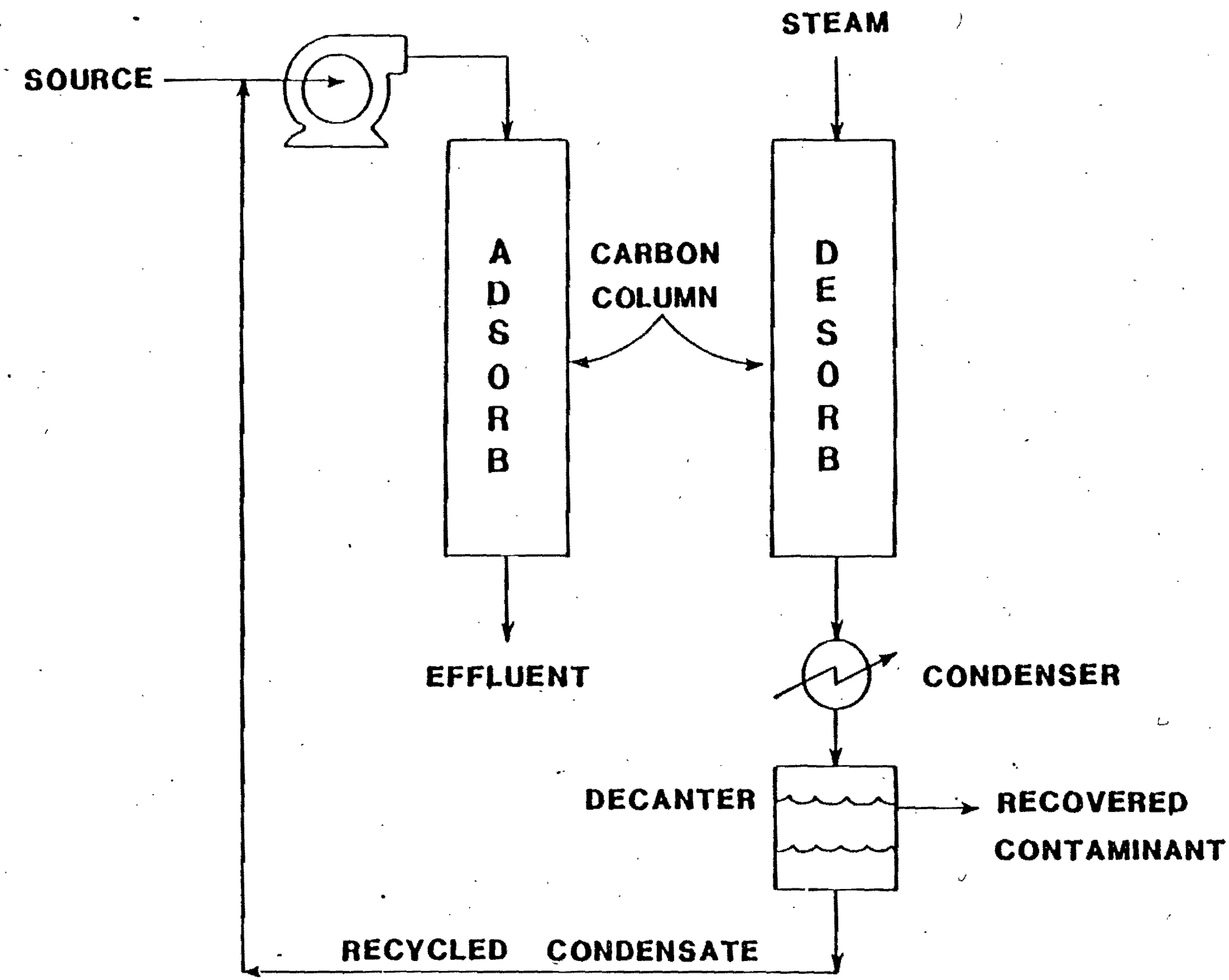


Figure 1. Steam Regeneration Flowsheet

steam/lb carbon to regenerate the carbon, a stable working capacity was maintained through the three regeneration cycles tested and effluent quality was good.

Based on the results of the experimental program, the following parameters were chosen as the design basis for a full-scale system:

- Hydraulic loading of 7 gpm/ft^2
- Minimum column height of 6 ft
- Regeneration with 10 lb steam/lb carbon at a rate of 2 lb/min ft^2

Using these design parameters, a design loading based on feed concentration, and a desired cycle time, a carbon adsorber can be sized. In the next section, calculations will be outlined for rough sizing of equipment. The quality of any detailed process design, however, is highly dependent upon experience and knowledge of the process. A final process design should always be prepared in consultation with a qualified carbon adsorption expert.

2. Equipment Specification

The heart of any carbon adsorption system is the adsorber vessel. The diameter of the vessel is set by the hydraulic loading and the flow rate. For example, the diameter of an adsorber designed to treat 200 gpm at 7 gpm/ft^2 would be calculated as follows:

$$(200 \text{ gpm}) \left(\frac{ft^2}{7 \text{ gpm}}\right) = 28.6 \text{ ft}^2$$

$$\frac{\pi D^2}{4} = 28.6 \text{ ft}^2\text{, so}$$

$$D = \left[\frac{(4)(28.6)}{\pi}\right]^{1/2} = 6 \text{ ft}$$

The height of the adsorber is then determined by the inlet concentration, the desired cycle time, and the organic loading on the carbon. For example, a 200 gpm feed containing 10 ppm (equivalent to 10 mg/l) total organics of interest (TOI) and having an expected regenerated carbon loading of 0.08 lb TOI/lb carbon (equivalent to 0.08 g TOI/g carbon), would result in the following carbon consumption:

$$\left(\frac{10\ \text{mg TOI}}{\text{liter}}\right)\left(\frac{3.8\ \text{liter}}{\text{gal}}\right)\left(\frac{200\ \text{gal}}{\text{min}}\right)\left(\frac{1\text{b C}}{0.08\ \text{lb TOI}}\right)\left(\frac{1\text{b TOI}}{454{,}000\ \text{mg TOI}}\right)\left(\frac{1440\ \text{min}}{\text{day}}\right) =$$

$$= 300\ \text{lb carbon/day}$$

If a two-week adsorption cycle was desired, the adsorber would have to hold 4200 lb carbon, or, at a density of 27 lb/ft^3, the capacity would be 156 ft^3. At a diameter of 6 ft, the required height would be just under 6 ft. This would be rounded to 6 ft, resulting in actual volume of 170 ft^3 and a carbon capacity of 4600 lb. A typical carbon adsorber specification is shown in Fig. 2.

Because activated carbon can create severe corrosion problems in a carbon steel vessel, special care must be taken in specifying materials of construction. Adsorbers used in applications where the carbon is removed for disposal or thermal regeneration are generally constructed of rubber- or epoxy-lined carbon steel. An adsorber designed for in-place, nondestructive regeneration will require stainless steel construction to accommodate the steam temperature.

Steam regeneration of carbon requires a heat exchanger (condenser) for condensation of the steam and organics and a vessel (decanter) for separation of the steam condensate and recovered organics. The steaming rate is based on the adsorber cross-sectional area and is calculated as follows:

$$\left(28.6\ \text{ft}^2\right)\left(\frac{2\ \text{lb}}{\text{min ft}^2}\right)\left(\frac{60\ \text{min}}{\text{hr}}\right) = 3400\ \text{lb/hr}$$

At 10 lb steam/lb carbon, the 4600 lb carbon bed sized above would require 46,000 lb of steam to regenerate. The steaming cycle would therefore be:

$$(46{,}000\ \text{lb})\left(\frac{\text{hr}}{3400\ \text{lb}}\right) = 13.5\ \text{hr}$$

The condenser duty would be based on the latent heat of the steam, which at atmospheric conditions would be 970 Btu/lb. The required duty would therefore be:

$$\left(\frac{3400\ \text{lb}}{\text{hr}}\right)\left(\frac{970\ \text{Btu}}{\text{lb}}\right) = 3.3 \times 10^6\ \text{Btu/hr}$$

PLANT	FILE JOB NO.
LOCATION	CHARGE NO.
MANUFACTURER	B/M NO.
	P. O. NO.

FIELD ERECTED YES NO X	NO. UNITS TWO (2)	TOTAL VOLUME 4200 GA[L]

DESIGN DATA

1	Operating Pressure	psig	10	
2	Operating Temperature	°F	Ambient	
3	Liquid Specific Gravity		1.0	
4	Contents Lethal		Yes No X	
5	Design Pressure	psig	50	
6	Design Temperature	°F	15-115	
7				
8				
9	Hydrostatic Test	psig	75	
10	Shell / Heads Corr. Allow.	In.	1/16	1/16
11	Shell / Heads Joint Eff.	%	**	**
12	Code: ASME		Stamp Yes X No	
13	Radiograph: Code		Stress Relieve: Code	
14	National Board No.			
15	Type Supports: Skirt			
16	Insulation: No			
17	Fireproofing: No			
18	Sandblast: Yes		Paint: Yes	
19	Manhole Hinged X Davited Other			
20	Platform Clips: 2	Ladder Clips: 1	Insul. Rings: No	
21	Pipe Supports: 2			
22	Wind Load: 110 mph		Seismic Zone 1	
23	Wt. Empty ** lb		Wt. Full of Water ** lb	

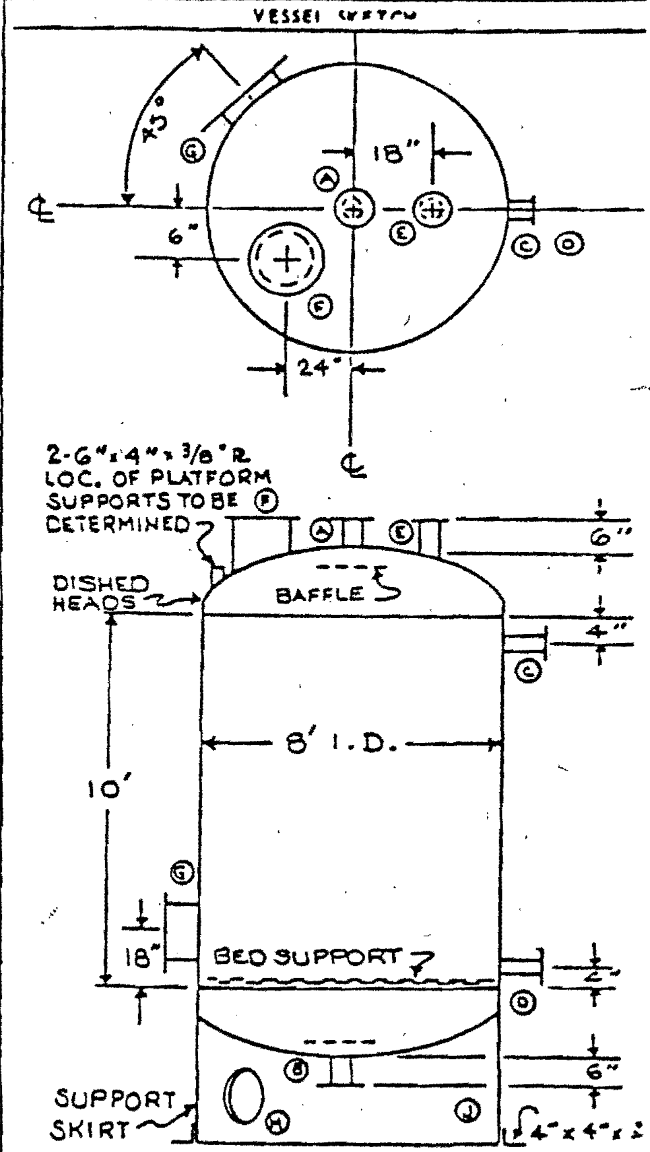
MATERIALS

	Item	Thickness	Mat'l Class	Mat'l - Minimum Quality
24	Item	Thickness	Mat'l Class	Mat'l - Minimum Quality
25	Shell	In.		316 S.S.
26	Heads	In.		316 S.S.
27	Lining	In.		
28		In.		
29		In.		
30	Nozzle Necks			316 S.S.
31	Flanges			316 S.S.
32	Coupling			316 S.S.
33	M.H. Cover			
34	Supports			
35	Bolts/Studs			
36	Nuts			
37	Gaskets			

NOZZLE SCHEDULE

No.	Service	Mark	No.	Size	Rating	Face	Type
38	Service	Mark	No.	Size	Rating	Face	Type
39	Inlet	A	1	4"	150#	RF	Flg.
40	Outlet	B	1	4"	150#	RF	Flg.
41	Car. Inlet	C	1	4"	150#	RF	Flg.
42	Car. Outlet	D	1	4"	150#	RF	Flg.
43	PSE	E	1	3"	150#	RF	Flg.
44	MH	F	1	20"	50#	RF	Flg.
45	MH	G	1	24"	50#	RF	Flg.
46	Skirt MH	H	1	20"			
47	Skirt Outlet	J	1	8"			
48		K					
49		L					
50		M					
51		N					
52		P					
53		Q					
54		R					
55	*Nozzle to be Plugged or Blinded						

VESSEL SKETCH



SPEC. BY RDA	Figure 2. Carbon Adsorber Specification					EQUIP. NO.
CHECKED:						VERTICAL VESSEL SPECIFICATIONS
APP'D:						
DATE:	REVISION DATE	A	B	C		SPEC. NO.
VENDOR TO COMPLETE ALL INFORMATION MARKED ___					SHEET OF	

218430 3-68

The decanter must be sized according to the anticipated flow of steam condensate and organic. The separation can be accomplished on a batch or continuous basis, depending on the specific application. In the case above, a batch separation would require a vessel capable of containing approximately 6,000 gallons of steam condensate and organic.

If a steam source is not available at the treatment site, a portable steam generator will be required. Specification of this unit basically requires the necessary steam supply rate and the desired steam supply pressure.

3. Capital and Operating Costs

ITE has prepared estimates of the treatment cost in terms of dollars per thousands of gallons of ground water treated. This treatment cost is a composite of the operating cost plus 30% of the installed equipment cost to cover depreciation, maintenance, and overhead. The installed equipment cost is defined as 3.5 times the estimated equipment purchase cost. The 3.5 composite installation factor is based on the components of the construction work required and is applied to the total purchased equipment cost. The composite factor includes engineering and other indirects adjusted as appropriate for the amount of vendor engineering (included in equipment purchase), the type of construction contracts, etc. The estimated purchased equipment costs are obtained from vendor quotes where appropriate or from data gathered from reliable cost estimating sources.

The costs presented are estimates for comparison of technologies or options on a general basis only. Evaluation of any technology or option for a specific application requires consideration of all the site-specific factors.

Two cost curves were prepared for the option of activated carbon adsorption with steam regeneration. The first curve, Fig. 3, represents treatment cost as a function of feed concentration. Table 1 outlines the components of the overall cost. A 200 gpm flowrate was assumed and treatment cost was evaluated at 1, 10, and 100 ppm TOI feed concentration. In this evaluation, a constant adsorber size was maintained, resulting in adsorption cycles of 2 days at 100 ppm, 15 days at 10 ppm, and 115 days at 1 ppm.

The second curve, Fig. 4, represents treatment cost as a function of flow rate. Table 2 outlines the components of the overall cost. 1, 10, and 100 ppm TOI feed concentrations were assumed and treatment cost was evaluated at 25, 100,

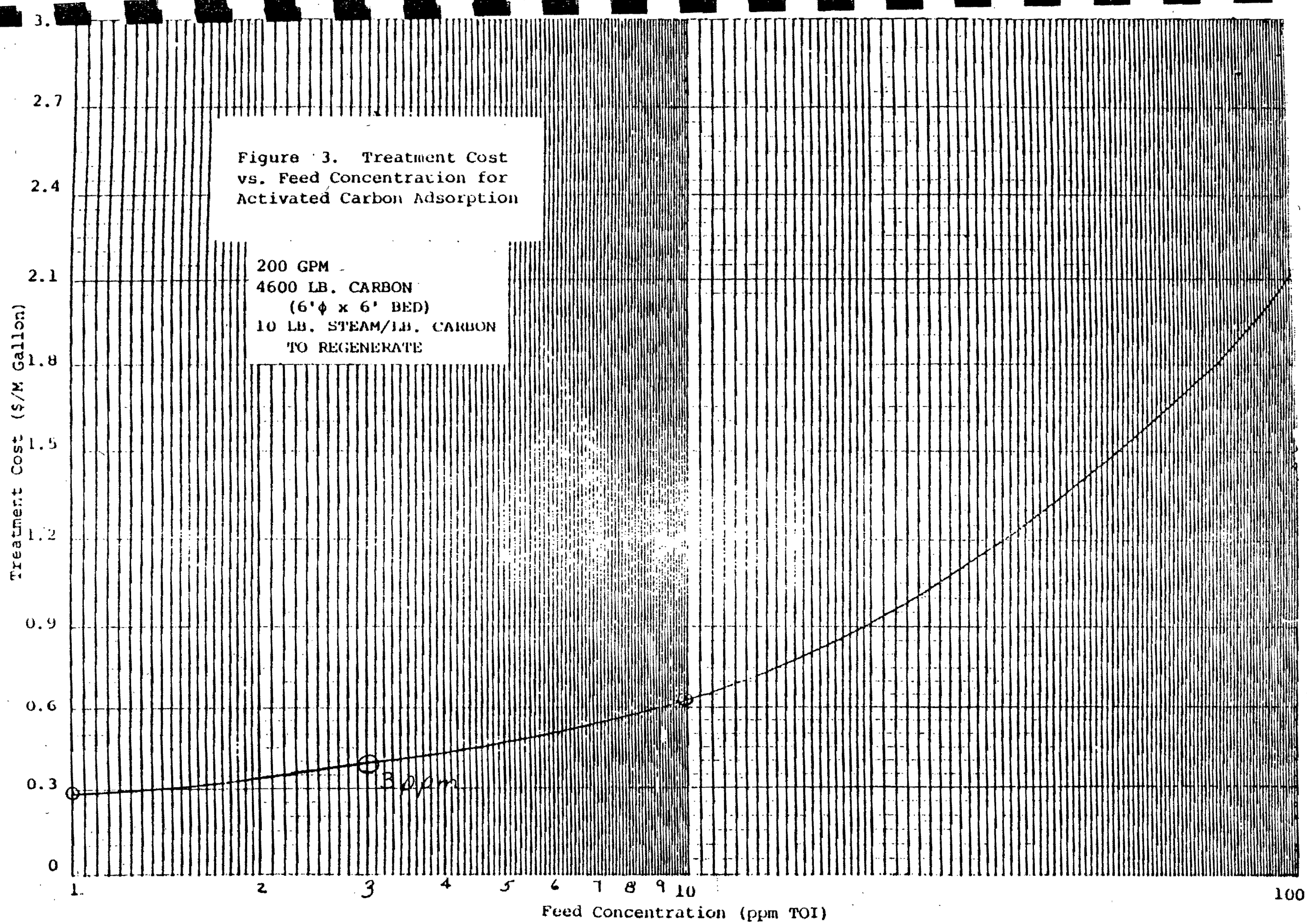


Figure 3. Treatment Cost vs. Feed Concentration for Activated Carbon Adsorption

Table 1. Treatment Costs at 200 gpm

Feed Concentration (ppm)	Purchased Equipment ($ M)	Operating[a] ($ M/yr)
1	25	4.6
10	40	24.4
100	40	181.6

[a]Not including labor.

3 ppm 40 9.0 - staight line

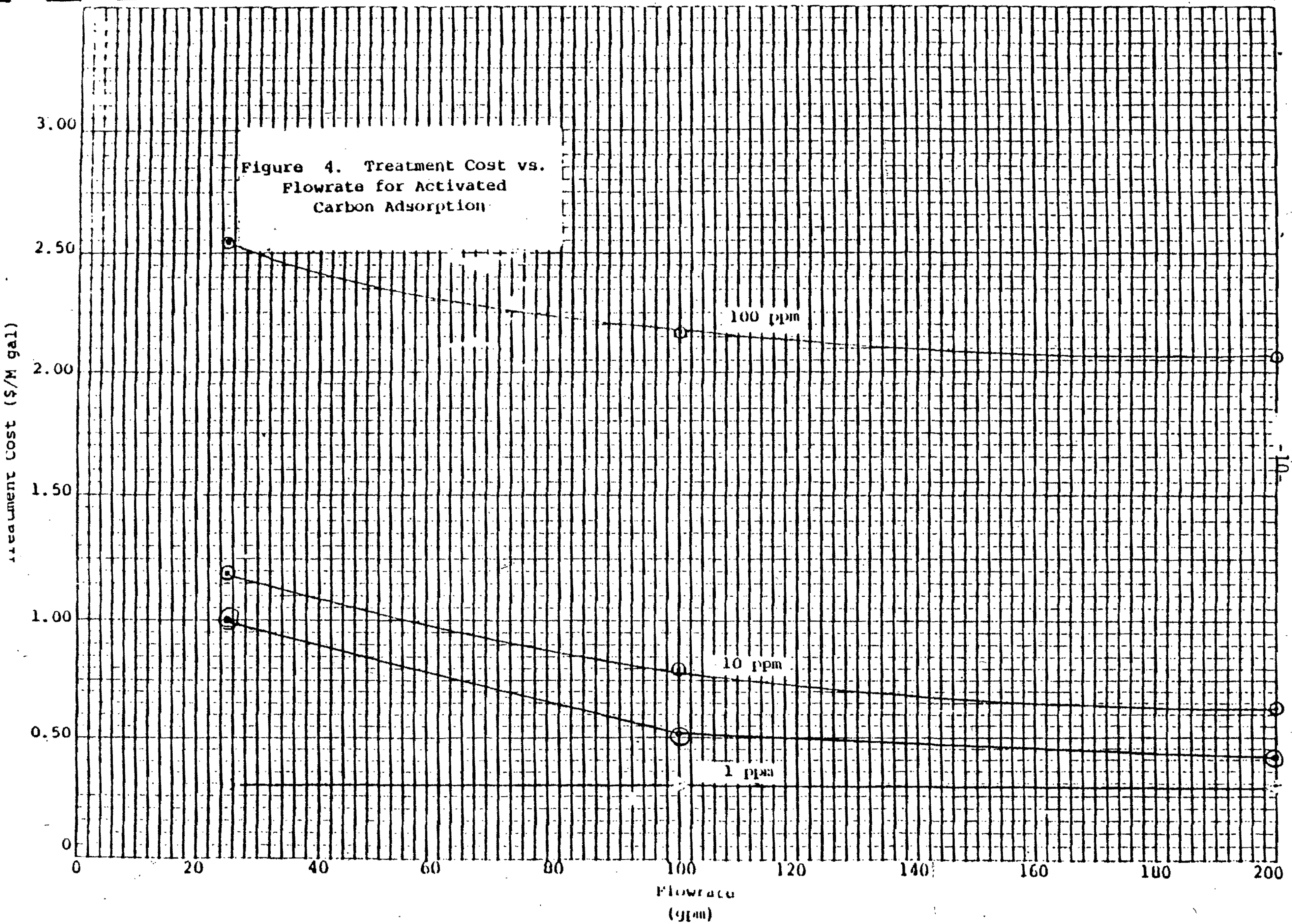


Figure 4. Treatment Cost vs. Flowrate for Activated Carbon Adsorption
100 ppm
10 ppm
1 ppm
Treatment Cost ($/M gal)
3.00
2.50
2.00
1.50
1.00
0.50
0
0
20
40
60
80
100
120
140
160
180
200
Flowrate
(gpm)

-10-

Table 2. Treatment Cost Comparison

	100 ppm[a]		10 ppm[b]		1 ppm[c]	
Flow Rate (gpm)	Purchased Equipment ($ M)	Operating[d] ($ M/yr)	Purchased Equipment ($ M)	Operating[d] ($ M/yr)	Purchased Equipment ($ M)	Operating[d] ($ M/yr)
25	12	21.1	12	3.1	12	0.4
100	25	87.0	25	14.8	25	1.5
200	40	174.4	40	24.5	40	3.0

[a] Based on 2 day cycle.

[b] Based on 14 day cycle.

[c] Based on 110 day cycle.

[d] Not including labor.

and 200 gpm for each. In this evaluation, adsorber sizes of 4400 lb carbon for 200 gpm, 2200 lb carbon for 100 gpm, and 550 lb carbon for 25 gpm were assumed.

Major equipment items for the activated carbon option included a 316 stainless steel adsorber, condenser, decanter, steam generator, and miscellaneous items such as pumps and a filter. In the case of 1 ppm TOI feed concentration, it was assumed that the steam generator would be rented as required, not purchased.

Operating costs included utilities (primarily cooling water and fuel for the steam generator; electrical requirements are minimal), rental of the steam generator when required, and carbon costs, but did not include labor. Carbon costs were based on the assumption that steam regenerated carbon would perform effectively for 10 cycles before requiring replacement of the carbon. This assumption was based on the fact that other process applications have reused carbon for more than 100 cycles. Although the experimental program only demonstrated performance through 3 cycles, no deterioration was observed. Actual full-scale regenerated carbon performance is likely to be highly dependent on site-specific conditions.

B. AIR STRIPPING

1. Process Description

Air stripping is usually one of the first technologies considered for ground water treatment applications. The major advantage of air stripping is its low overall treatment cost. Both capital and operating cost requirements are low compared to most other technologies, and it is a relatively simple technology to operate.

The key to air stripping's low overall treatment cost is the assumption that it can stand alone as a treatment technology. In some cases, air emission standards will require that air stripping be used in conjunction with vapor treatment such as a vapor-phase adsorption unit. Because of the large air flows associated with ground water applications, the cost of a vapor-phase adsorption unit could be quite high relative to the air stripping unit, significantly affecting the cost-effectiveness of the overall option. This consideration will be addressed more completely in Section II-C, Activated Carbon/Air Stripping.

Another disadvantage demonstrated by the experimental results is that air stripping is temperature-sensitive. Decreasing temperature will decrease the removal efficiency. Since ground water is normally in the range of 10 to 15°C, larger columns or preheating of the ground water may be required.

The design of an air stripping system is based on economic tradeoffs between higher operating costs associated with high air/water ratios or higher capital cost associated with a taller column. Actual design of a system will be highly dependent on the type of packing chosen and, of course, the operating conditions (flow rate, air/water ratio, temperature, desired removal efficiency, etc.). In the next section, calculations will be outlined as an example of how an air-stripping system should be designed.

The normal design procedure for an air stripping column requires a knowledge of the vapor-liquid equilibrium data for the components of interest.[5] Because air stripping was evaluated as a follow-up treatment to activated carbon, the experimental work was focused on treatability of the oxygenated compounds. The assumption was made that the pilot plant performance could be assessed based on MTBE removal in the column (TBA was not effectively stripped). Unfortunately, no experimental vapor-liquid equilibrium data for MTBE has been located, and ITE has been forced to use a theoretical correlation.

Use of the theoretical vapor-liquid equilibrium would predict that MTBE could not be stripped from water at the 2 cfm/gpm process condition to the extent that ITE's experimental data showed. Knowledge that the theoretical vapor-liquid equilibrium line does not represent actual conditions indicates that the correlations between ITE's pilot-scale column and a full-scale design are inaccurate to some degree, but the real correlation cannot be established without experimental vapor-liquid equilibrium data.

2. Equipment Specification

The basic components of an air stripping system are the packed column and the air blower. The diameter of the column can be estimated through use of pressure drop correlations such as those that are shown in Fig. 5 and which were provided by Norton Chemical Processing Products.[6] For a system with an air/water ratio of 10 cfm/gpm operating at 10°C, the abscissa of the graph can be found by:

$$\frac{L}{G}\sqrt{\frac{\rho g}{\rho L}} = \left(\frac{\text{min}\cdot\text{gal}}{10\ \text{ft}^3\ \text{min}}\right)\left(\frac{\text{ft}^3}{0.078\ \text{lb}}\right)\left(\frac{8.3\ \text{lb}}{\text{gal}}\right)\left[\frac{(0.078\ \text{lb/ft}^3)}{(62.4\ \text{lb/ft}^3)}\right]^{0.5} = 0.38$$

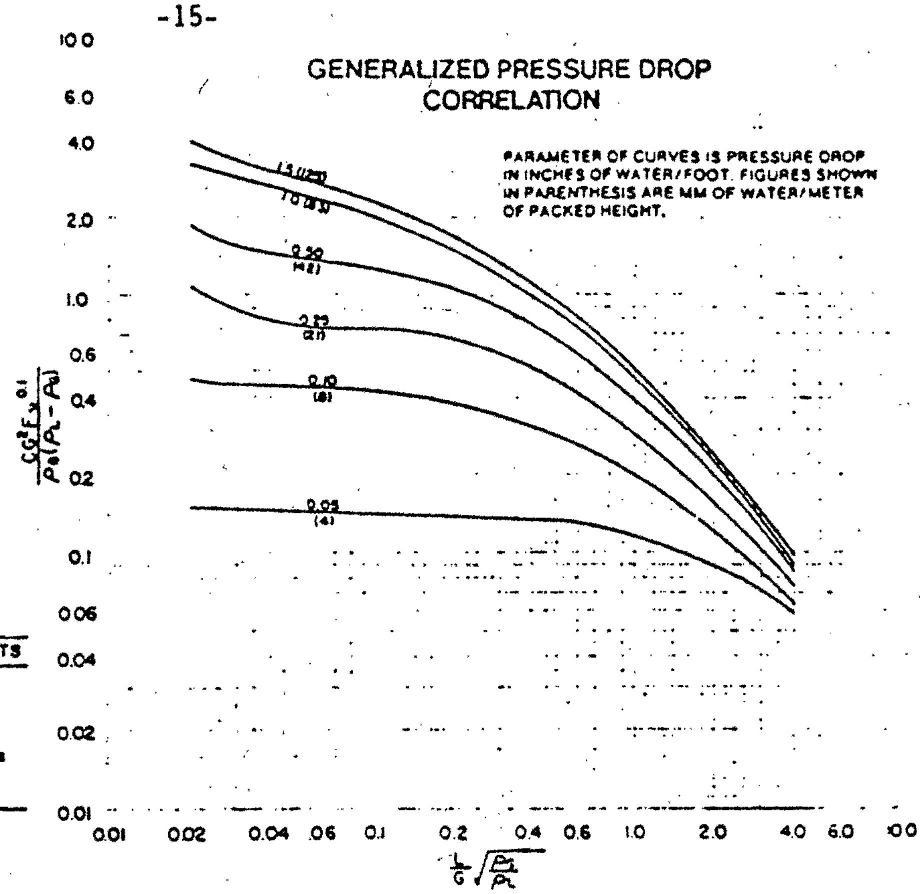
Assuming an allowable pressure drop of 0.5 in. H_2O per foot of packing, the ordinate value can be read as 0.8. From this value, G can be calculated for a system using 1 in. ceramic Raschig rings by:

$$G = \left[\frac{Y\ \rho G\ (\rho L - \rho G)}{C F \upsilon^{0.1}}\right]^{0.5}$$

$$= \left[\frac{(0.8)(0.078)(62.4-0.078)}{(1)(155)(1.5)^{0.1}}\right]^{0.5} = \frac{0.155\ \text{lb}}{\text{ft}^2\cdot\text{sec}}$$

If 200 gpm are being treated, the air requirement will be 2000 cfm. The cross-sectional area of the column can then be found by:

Design Techniques for Sizing Packed Towers



GENERALIZED PRESSURE DROP CORRELATION

PROPERTY	SYMBOL	BRITISH UNITS	METRIC UNITS
Gas Rate	G	Lbs/ft² sec	KG/M² s
Liquid Rate	L	Lbs/ft² sec	KG/M² s
Gas Density	ρ_G	Lbs/ft³	KG/M³
Liquid Density	ρ_L	Lbs/ft³	KG/M³
Liquid Viscosity	ν	Centistokes	Centistokes
Conversion Factor	C	1.000	10.764
Packing Factor	F	—	—

Packing Factors
(DUMPED PACKING)

Packing Type	Mat'l.	Nominal Packing Size (Inches)										
		¼	⅜	½	⅝	¾	1 or #1	1¼	1½	2 or #2	3	3½ or #3
Hy-Pak™	Metal						43			18		15
Super Intalox® Saddles	Ceramic						60			30		
Super Intalox Saddles	Plastic						33			21		16
Pall Rings	Plastic				97	–	52		40	24		16
Pall Rings	Metal				70		48		33	20		16
Intalox® Saddles	Ceramic	725	330	200		145	92		52	40	22	
Raschig Rings	Ceramic	1600	1000	580	380	255	155	125	95	65	37	
Raschig Rings	1/32" metal	700	390	300	170	155	115					
Raschig Rings	1/16" metal			410	290	220	137	110	83	57	32	
Berl Saddles*	Ceramic	900		240		170	110		65	45		

Packing factors determined with an air-water system in 30" I.D. tower

$$A = \left(\frac{2000\ ft^3}{min}\right)\left(\frac{0.078\ lb}{ft^3}\right)\left(\frac{min}{60\ sec}\right)\left(\frac{ft^2 \cdot sec}{0.155\ lb}\right) = 16.8\ ft^2$$

$$\frac{\pi D^2}{4} = 16.8\ ft^2, \text{ so}$$

$$D = \left[\frac{(4)(16.8)}{\pi}\right]^{0.5} = 4.6\ ft$$

The height of the adsorber can then be determined from the number of stages required to achieve a desired overall removal efficiency and the height per stage for a specific packing. For example, if 15 stages are required to achieve a 99.9% removal efficiency (from an inlet concentration of 10 ppm to an outlet concentration of 10 ppb) and vendor literature indicates that 2 ft of a particular packing is equivalent to a stage, then the column height would be 30 ft. The required amount of packing can then be calculated from the column volume.

Materials of construction are less of a concern with air stripping than with carbon adsorption. Stripping columns can generally be constructed from FRP (fiberglas-reinforced plastic).

The blower for an air stripping system can be roughly sized by the following formula:

$$\text{Brake Horsepower} = \text{BHP} = \frac{(\text{cfm})(\Delta P)}{(6356)(\text{Efficiency})}$$

For the system described above, assuming a 65% efficiency, the blower brake horsepower would be:

$$\text{BHP} = \frac{(2000\ \text{cfm})(15\ \text{in. } H_2O)}{(6256)(0.65)} = 7.26$$

3. Capital and Operating Costs

Estimates of the treatment cost of air stripping have been prepared in terms of dollars per thousands of gallons of ground water treated. The basis for this treatment cost calculation was described in the activated carbon adsorption section of this report.

A cost curve has been prepared for the option of air stripping. All costs in this evaluation assume that air stripping can be used as a stand-alone technology and will not require vapor-phase adsorption to meet emission standards.

The curve, Figure 6, represents treatment cost as a function of flowrate. Table 3 outlines the components of the treatment costs. An air/water ratio of 20 cfm/gpm was assumed and treatment cost was evaluated at 25, 100, and 200 gpm. The column diameters were again established based on a pressure drop of 0.5 in. H_2O/ft packing. The overall column height was the same in each case.

Major equipment items for the air stripping option included the column, blower, and miscellaneous items such as pumps and a filter. Operating cost included only the electrical cost associated with the blower.

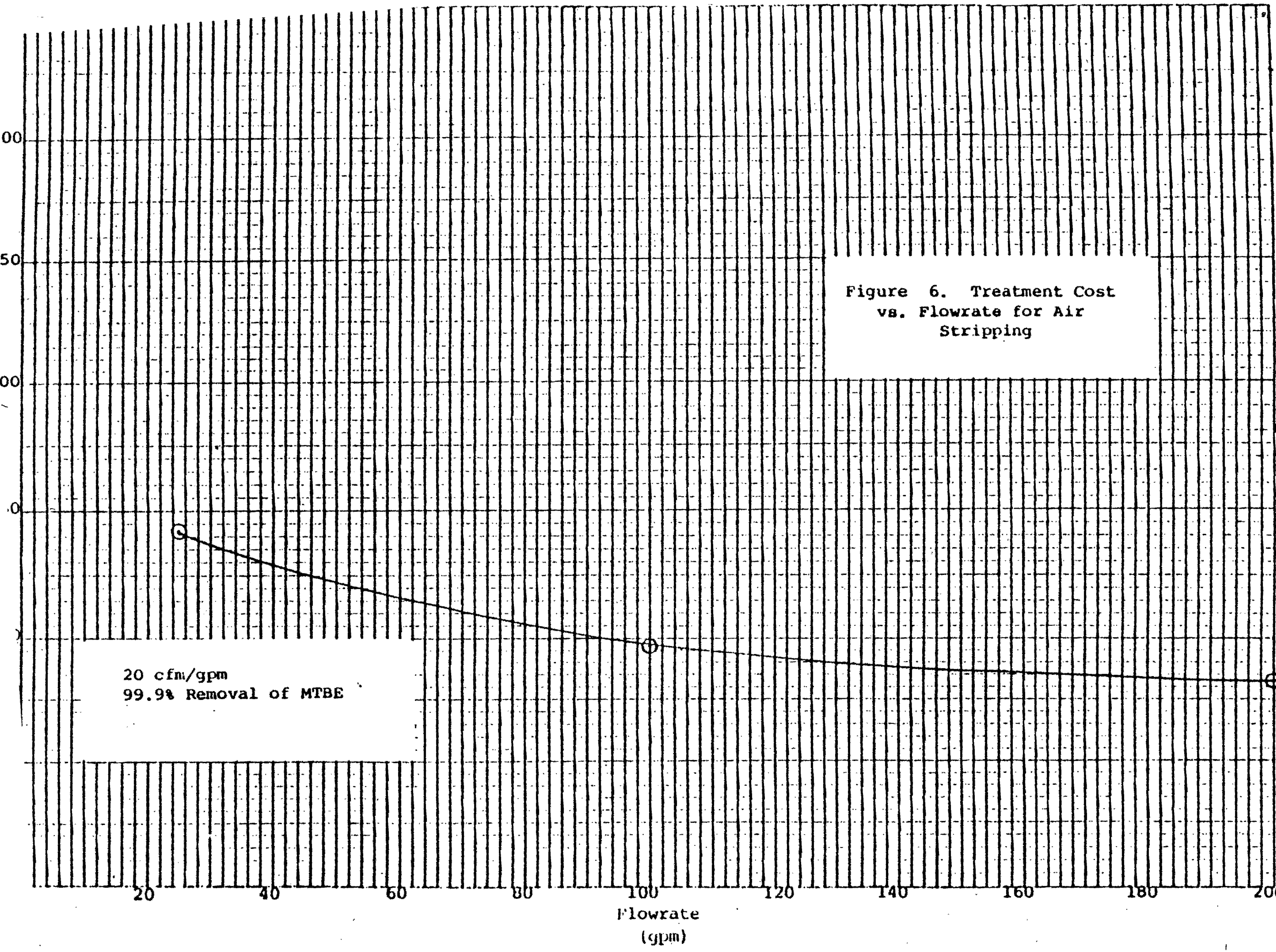


Figure 6. Treatment Cost vs. Flowrate for Air Stripping

Table 3. Treatment Cost at 20 cfm/gpm

Flow Rate (gpm)	Purchased Equipment ($ M)	Operating[a] ($ M/yr)
25	16	1.3
100	44	5.4
200	72	10.8

[a]Not including labor.

C. ACTIVATED CARBON/AIR STRIPPING

1. Process Description

The option of combining activated carbon adsorption and air stripping may be applicable in specific cases. The activated carbon experimental work indicated that carbon adsorption was relatively ineffective for removal of the oxygenates (MTBE and TBA), but very effective for treatment of the aromatic compounds. Air stripping, on the other hand, was effective in removing all components except TBA. Consideration could be given, then, to the option of using air stripping to treat the effluent from a liquid-phase carbon adsorption unit to remove MTBE.

The other technology combination that could be considered would be air stripping followed by vapor-phase carbon adsorption. This option might be employed to meet emission standards imposed on an air stripping system. This would be likely to occur only in a high treatment volume, high feed concentration case or in a severe regulatory atmosphere. If vapor-phase carbon adsorption were required, air stripping could lose its cost advantage and liquid-phase carbon adsorption might become the technology chosen.

2. Capital and Operating Costs

The overall treatment cost for carbon adsorption followed by air stripping to remove MTBE would simply be the additive cost of each of the technologies on a stand-alone basis. Figure 7 represents a cost curve for the treatment of 25, 100, and 200 gpm at the specified operating conditions.

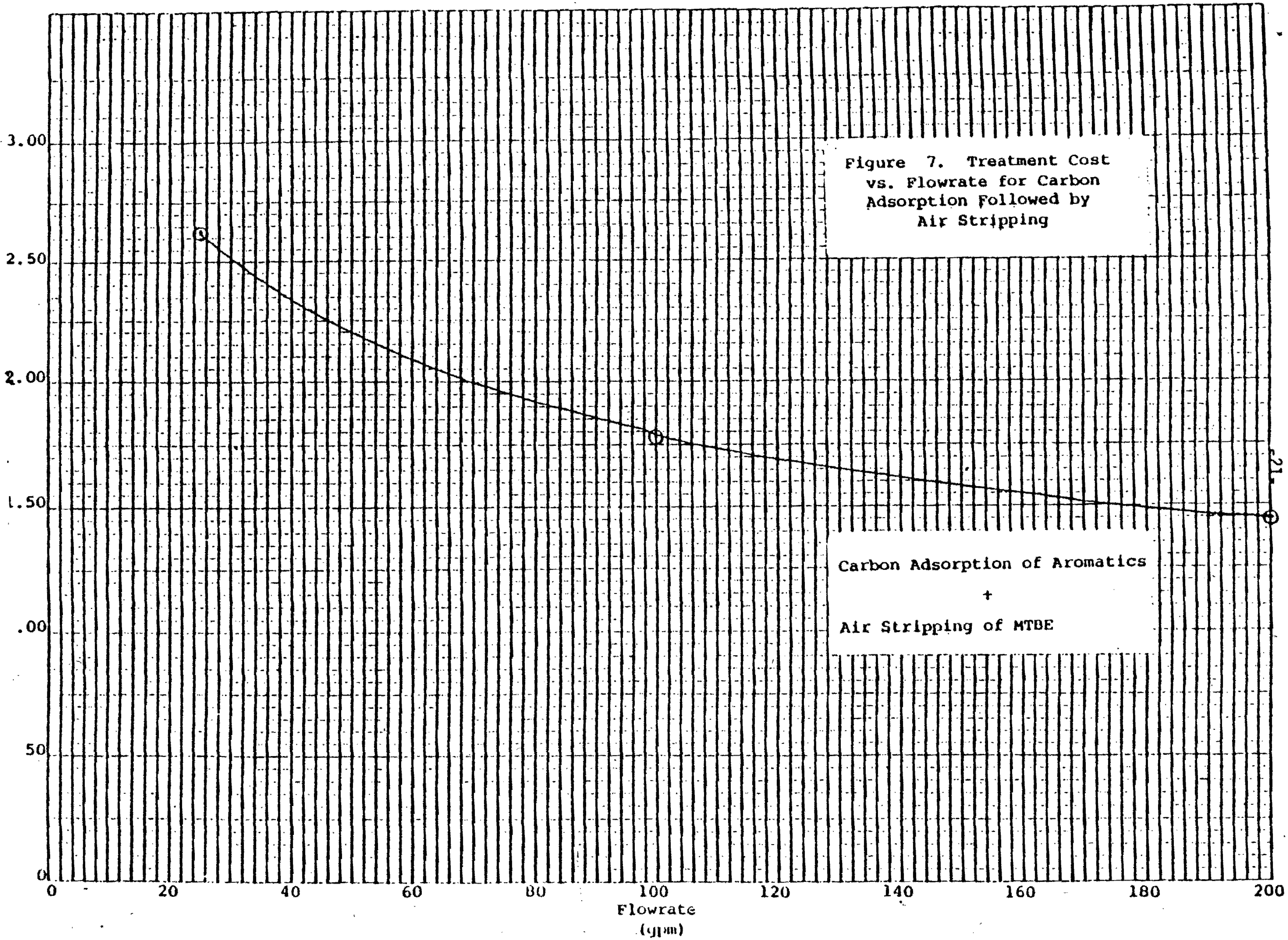


Figure 7. Treatment Cost vs. Flowrate for Carbon Adsorption Followed by Air Stripping

D. LAND APPLICATION

1. Process Description

In selected situations, land application of gasoline contaminated ground water may be a viable alternative. Land application basically utilizes natural processes, such as volatilization, biodegradation, or adsorption on the soil, to decontaminate the ground water. The potential use of land application will be very site specific, depending mostly on the volume of water to be treated and the availability of an application site in the immediate area.

Proper evaluation of a site for land application requires analysis of a number of factors. Of greatest concern is the overall site permeability, proximity to ground water or surface water sources, and permitting requirements. Characterization of the microorganisms in the soil is necessary to determine the potential for biodegradation, and the potential for volatilization and adsorption on the soil will be functions of the site's ambient weather conditions and soil makeup, respectively.

The API is presently funding research to study the natural fate of aqueous gasoline components in the environment, a project that will address most of the basic mechanisms involved in land application. Results of that project will more clearly define the potential role of land application.

2. Capital and Operating Costs

Because land application is likely to be a viable option for the treatment of a small volume of contaminated ground water, a commercially available site within reasonable hauling distance is a requirement. It is unlikely that a single contaminated ground water site would provide economic justification for the capital investment required for purchasing land and equipment for a dedicated land application site.

Utilization of a commercial land application site would involve costs for hauling of the ground water to the site and a disposal fee. Typical costs for these services would be approximately $50 per hour for a 4000-gal truck and approximately $0.10 per gal for disposal. Assuming that a suitable site is available within an hour's drive, disposal cost would be approximately $125 per thousand gallons. This results in a treatment cost per thousand gallons that is much higher than the treatment costs associated with activated carbon or air stripping. Land application would likely be a cost-effective solution only in small volume applications (say, less than 20,000 gallons).

E. TECHNOLOGY COMPARISON

1. Applicability

Both activated carbon adsorption and air stripping are considered widely for ground water treatment. The choice of a particular technology for a specific application will depend on a number of factors. Economic considerations will be of prime interest, but it must be established that the technology being considered is applicable to the situation. For example, the inlet concentration and the volume to be treated must be considered. For low concentration, low volume applications the treatment cost differential between carbon adsorption and air stripping is likely to be low enough that a decision can be based on availability and ease of installation and operation. For high volume, high concentration applications air stripping is most cost effective if air emissions are not a problem. Carbon adsorption is more expensive on a stand-alone basis, but may become more economical if emission treatment such as a vapor-phase carbon system is required in conjunction with the air stripping system.

Another consideration is utility cost. Treatment costs for carbon adsorption with nondestructive regeneration tend to reflect high initial capital investment and low operating costs while treatment costs for air stripping generally reflect the opposite, especially at high air/water ratios. In areas where electrical costs are higher than average, air stripping may lose some of its cost advantage.

A final consideration is the desired effluent quality. ITE's calculations show that for air stripping, a minimum air/water ratio of 15 cfm/gpm would be required to achieve 99.9% removal efficiency for MTBE. This value may not be totally accurate due to the uncertainty associated with the vapor-liquid equilibrium line, but it is representative of the range of air/water ratios required to achieve the desired effluent quality in ground water applications.

As discussed earlier, the potential use of land application will be very site-specific. This option will probably only be viable for small volume applications where a site is readily available.

2. Comparative Costs

Figure 8 represents a comparison of treatment cost vs. flow rate for activated carbon adsorption and air stripping at an inlet concentration of 10 ppm TOI. The treatment costs are not significantly different over the range of flow

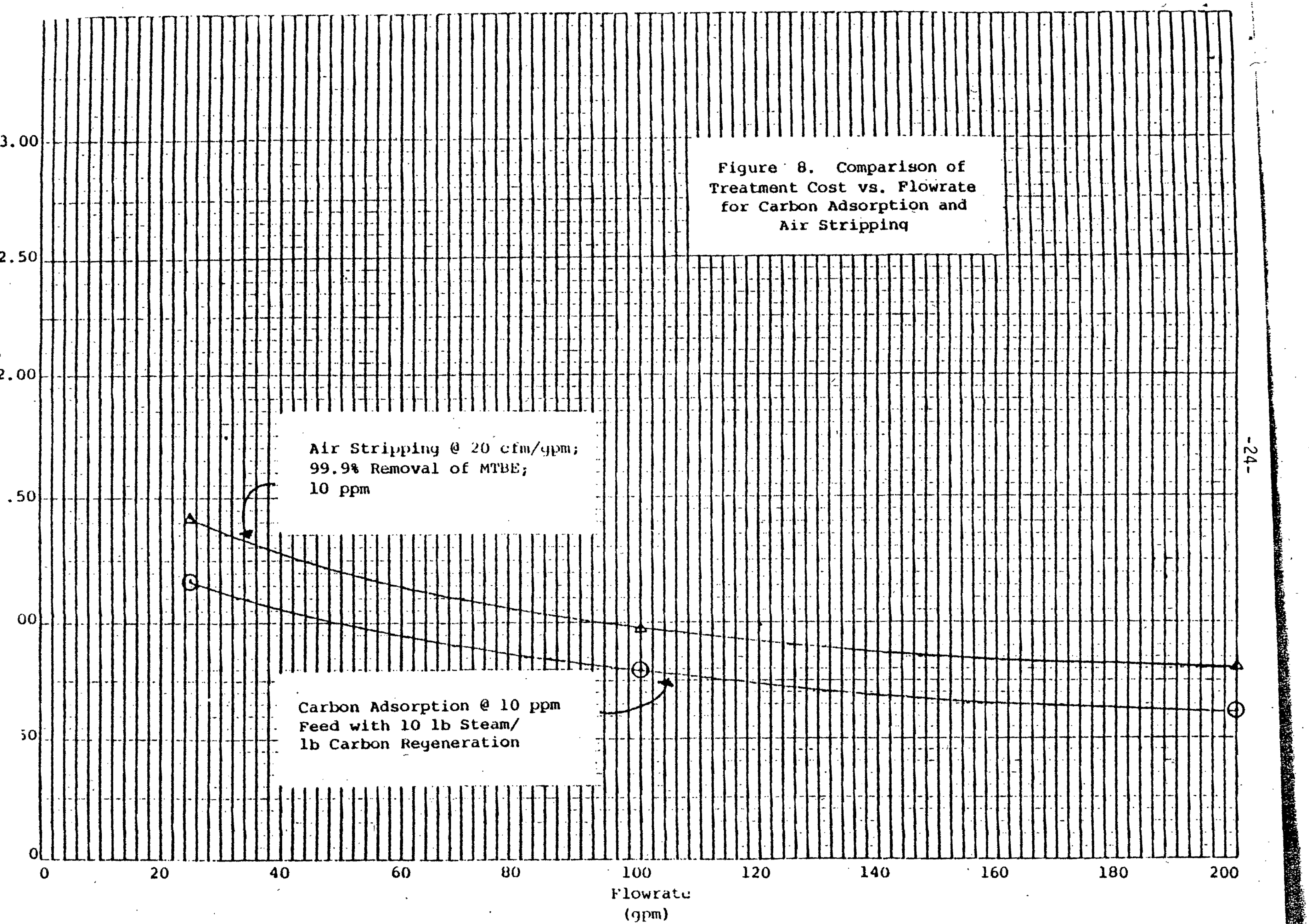


Figure 8. Comparison of Treatment Cost vs. Flowrate for Carbon Adsorption and Air Stripping

rates. Figure 9 represents a comparison of treatment cost vs. feed concentration for activated carbon and air stripping at a flow rate of 200 gpm. As the graph shows, air stripping treatment cost is not a function of concentration and stripping gains a cost advantage over carbon adsorption as concentration increases. Note that this conclusion is based on an assumption that the treatment goal for an air stripping system is 99.9% removal regardless of inlet concentration. If specification of an effluent concentration requires a removal efficiency of greater than 99.9%, the treatment cost for air stripping will be a function of concentration because the stripping column will need to be taller and/or because a higher air/water ratio will be required.

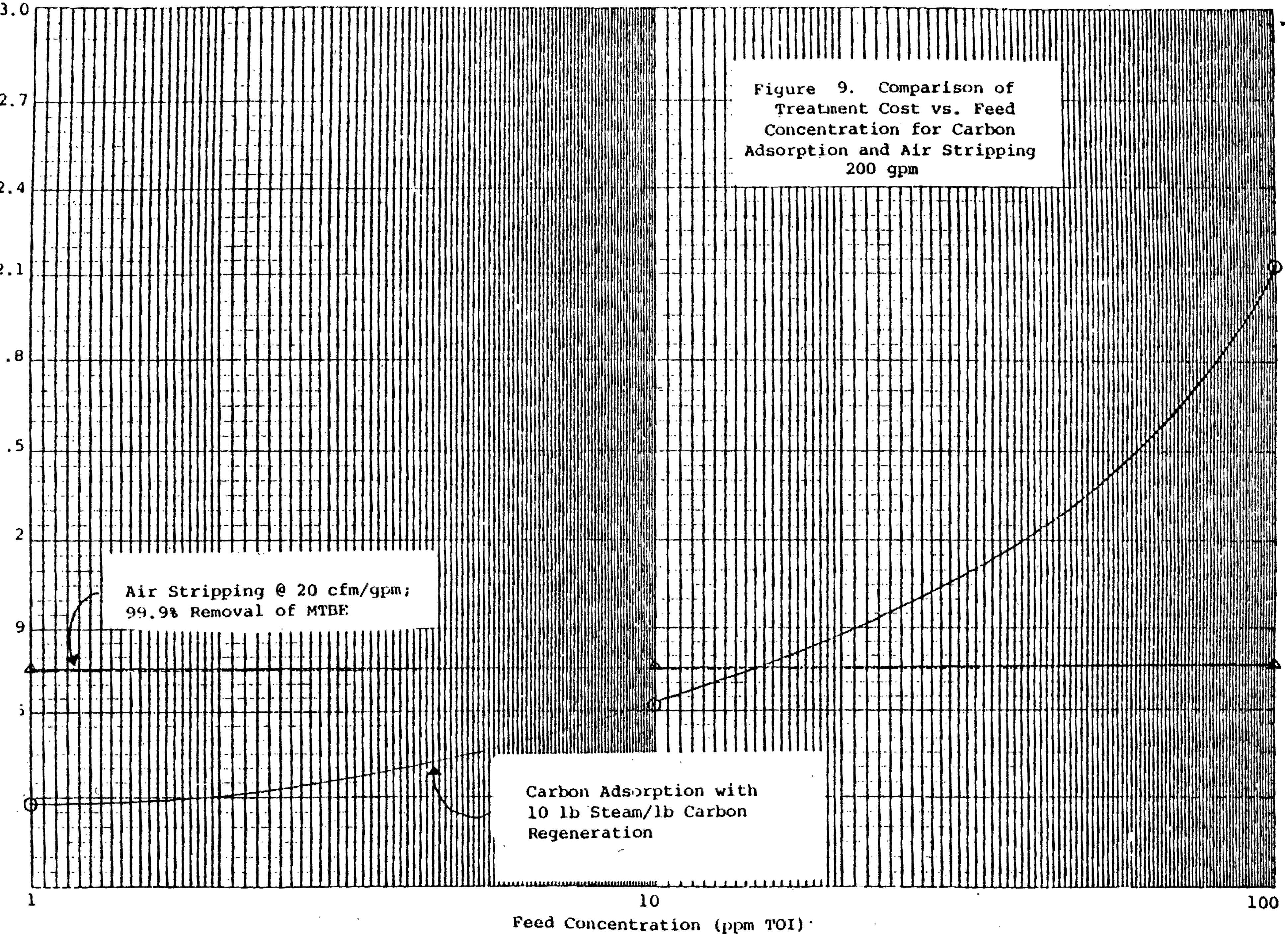


Figure 9. Comparison of Treatment Cost vs. Feed Concentration for Carbon Adsorption and Air Stripping 200 gpm

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Appendix D

Soil Vacuum Extraction System

Cost Estimates

RMT INC.

DESIGN SHEET

Cost Estimate SHEET ______ OF ______

11 Regency Hills Drive, P.O. Box 16778 Greenville, S.C. 29606 (803) 292-1921

PROJECT / PROPOSAL NAME	PREPARED By:	Date:	CHECKED By:	Date:	PROJECT/PROPOSAL NO.
Vacuum Extraction System					

Basis: 23 wells
3,500 ft of pipe

per Ed Malmonis at Terra Vac 813-335-5374

$3,000 materials (adaptors, gages, block head)

$70,000 piping (@ $20/ft)

5,000 well head

#360,000 rent of vacuum system for 18 months from Terra Vac with monthly monitoring @ #20,000/month

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sub total #438,000

66,000 engineering 15%

66,000 contingency 15%

Total #570,000

Appendix E

Discharge Cost to Surface Bodies

RMT INC.

DESIGN SHEET

11 Regency Hills Drive, P.O. Box 16778 Greenville, S.C. 29606 (803) 292-1921

SHEET ____ OF ____

PROJECT / PROPOSAL NAME	PREPARED By:	Date:	CHECKED By:	Date:	PROJECT/PROPOSAL NO.
Discharge to Surface Water					

Cost estimates for NPDES permit discharge to Cooper River or Goose Creek.

Assumptions : 1) Gravity flow with 40 ft head at site
2) Max flow 200 gpm
3) Pipe buried in 5 ft. trench

For 8,000 ft to the Cooper River

	quantity	price	cost
pipe 8" PVC	8,000 ft	$5/ft	$40,000
excavation	10,400 yd³	3/yd³	$31,200
backfill	9,000 yd³	5.5/yd³	$49,500
manholes			$40,000
		sub total	160,700
	Engineering	15%	24,105
	Contingency	15%	24,105
			#208,910
		use	# 225,000

RMT INC.
11 Regency Hills Drive, P.O. Box 16778 Greenville, S.C. 29606 (803) 292-1921

DESIGN SHEET

SHEET ______ OF ______

PROJECT/PROPOSAL NAME	PREPARED By:	Date:	CHECKED By:	Date:	PROJECT/PROPOSAL NO.
Discharge to Surface Bodies					

For 5,000 ft to the Cooper River

	quantity	price	cost
pipe 8" PVC	5,000 ft	$5/ft	25,000
excavation	6,500 yd³	3/yd³	19,500
back fill	5,600 yd³	5.5/yd³	30,937
manholes			25,000
		sub total	100,437
		Engineering 15%	15,065
		Contingency 15%	15,065
			$130,568

USE $150,000

Appendix F

Air Emmissions Calculations

RMT INC.

DESIGN SHEET

SHEET ____ OF ____

11 Regency Hills Drive, P.O. Box 16778 Greenville, S.C. 29606 (803) 292-1921

PROJECT / PROPOSAL NAME	PREPARED By:	Date:	CHECKED By:	Date:	PROJECT/PROPOSAL NO.
Air Emissions from Stripping					

Given: 200 gpm ground water

3,000 ppb or 3 ppm

Assume 100% removal during stripping

$\frac{3\ mg}{l} \times 8.34 \times MGD = lb/day$

$\frac{3\ mg}{l} \times 8.34 \times 0.288 = 7.2\ lb/day \approx \frac{8\ lb}{day}$